# Application of HEC-HMS model for runoff simulation

A Thesis Presented in Partial Accomplishment of the requisite for the degree of

**BACHELOR OF TECHNOLOGY**

In

Civil Engineering

By

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# NATIONAL INSTITUTE OF TECHNOLOGY ROURKELA

## CERTIFICATE

This is to certify that the thesis id entitled, "**Application of HEC-HMS model for runoff simulation**" submitted by SANDEEP KUMAR SAHU in partial fulfilment for the requirement for the degree of Bachelor of Technology 2015-16 in **Civil** Engineering at **National Institute of Technology, Rourkela** is an authentic work carried out by him under my supervision and guidance. To the best of my knowledge, the matter embodied in this report has not been submitted to any other University/Institute for the award of any Certificate.

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# ABSTRACT

Hydrologic modelling includes the mathematical models to represent the hydrologic processes such as, precipitation, snowmelt, interception, evapotranspiration, infiltration, sub-surface flow, and surface flow, as well as the interaction between them. Hydrological modeling is a challenging because it includes highly nonlinear processes, complexity and highly spatial variability at basin. Physically based hydrological models are based on known scientific principles of energy and water fluxes whereas, conceptual models are based on conceptual storages and various model parameters that require calibration, or they are moisture accounting models without explicitly considering energy fluxes, and so they mimic physical processes in a simplified manner. Focus on the physically based distributed hydrologic modelling started in order to minimize or overcome the deficiencies of the conceptual models. In physically based hydrologic modelling the hydrologic process of water movement are modeled either by the finite difference approximation of the partial differential equation representing the mass, momentum and energy balance or by empirical equations. Typically the primary components of hydrologic cycle related to the land phase are taken into consideration. These are: interception, snowmelt, evapotranspiration, sub-surface runoff, groundwater flow, surface runoff and channel routing. Physically based hydrologic models can be fully distributed where a river basin is discretized as a rectangular grid mesh, or be semi-distributed when the basin is divided into limited number of sub basins based on the terrain features and the drainage network. Study and simulation of a watershed has been done using HEC-HMS. The Silsako watershed located in Guwahati city has been modelled and the peak simulated discharge obtained at the outlet of the watershed is 6793815.6 $m^3$.

# CONTENTS

# CHAPTER 1

## OVERVIEW

Hydrology is the study of the water cycle that includes the knowledge of water evaporation from sea and land. Where and how much water returns back to the earth's surface as precipitation and how much it get stored in soils and aquifers, as well as how water travels through rivers and underground to the seas and oceans. Hydrologists help solve local and global problems related to the overabundance, scarcity, or quality of water, by understanding various physical, chemical, and biological processes in the water cycle and soil-water system.

From the beginnings, there is dependably worry over the conceivable outcomes of a dangerous atmospheric deviation, it has been broadly perceived that adjustments in the water cycle between area, ocean, and air could have exceptionally huge effects crosswise over numerous divisions of the economy, society, and nature. The attributes of numerous physical biological systems, for instance, are vigorously impacted by water accessibility and, on account of in stream environments and wetlands, by the amount and nature of water in waterways and aquifers. Water is basic for the human life and numerous exercises—most clearly horticulture additionally industry, power era, transportation, and waste administration—and the accessibility of clean water frequently is an imperative on monetary improvement. Thusly, there have been a considerable number studies into the potential impacts of environmental change on hydrology (concentrating on cycling of water) and water assets (concentrating on human and natural utilization of water).

Waterway bowl or a watershed is a territory over which different hydrologic procedures, for example, precipitation, snowmelt, capture attempt, evapotranspiration, invasion, surface overflow, and sub-surface stream are performed. Hydrological demonstrating includes figuring the scientific models to speak to these hydrologic forms and additionally the collaboration between them. So in hydrologic displaying the between relationship of soil, water, atmosphere, and area use are viewed as and spoke to through numerical reflection (Gosain et al., 2009). This can challenge since it includes exceptionally nonlinear procedures, complex communications and high spatial variability at bowl scale.

Hydrological models can be classified by physical procedures required in displaying and also the reasonable and physically based (Refsgaard, 1996) models. In reasonable models each of the hydrologic forms, that we read into our perceptions of the catchment, are spoken to by disentangled numerical connections, where as in physically based model the subtle element physical procedures can be spoken to deterministically by representations of mass, force and vitality protection.

**CHAPTER 2**

# LITERATURE ASSESSMENT

- M. M. G. T. De Silva (2014) have studied a case study of incident and constant hydrologic modelling in the Kelani River basin in Sri Lanka using the Hydrologic Engineering Centre—Hydrologic Modelling System (HEC–HMS). An enormously high rainfall incident in the spring month of the year 2005 was used to calibrate model parameters, and tremendously high rainfall incidents in 2008 and 2010 were used to evaluate the efficiency of the epitome. The standardised, uninterrupted runoff and base flow attributes were utilized in the constant hydrologic model.
- D. Halwatura (2013) have described Hydrologic simulation employing computer models has advanced rapidly and computerized models have become essential tools for understanding human influences on river flows and designing ecologically sustainable water management approaches. The HEC-HMS is a reliable model developed by the US Army Corps of Engineers that could be used for many hydrological simulations. This model is not calibrated and validated for Sri Lankan watersheds and need reliable data inputs to check the suitability of the model for the study location and purpose. Therefore, this study employed three different approaches to calibrate and validate the HEC-HMS 3.4 model to Attanagalu Oya (River) catchment and generate longterm flow data for the Oya and the tributaries.
- M.R. Knebl (2004) have develops a framework for regional scale flood modeling that integrates NEXRAD Level III rainfall, GIS, and a hydrological model (HECHMS/RAS). The San Antonio River Basin (about 4000 square miles, 10,000 km2) in Central Texas, USA, is the domain of the study because it is a region subject to frequent occurrences of severe flash flooding. A major flood in the summer of 2002 is chosen as a case to examine the modeling framework. The model consists of a rainfall–runoff model (HEC-HMS) that converts precipitation excess to overland flow and channel runoff, as well as a hydraulic model (HEC-RAS) that models unsteady state flow through the river channel network based on the HEC-HMS-derived hydrographs.
- Reshma T (2013) have estimated accurate runoff for a given rainfall event is a difficult task due to various influencing factors. Several computer based hydrological model have been developed for simulation of runoff in watershed and water resource studies.

In this study, Hydrologic Engineering Center –Hydrologic Modeling System (HECHMS) hydrological model has been used to simulate runoff process in Walnut Gulch watershed located in Arizona, USA. To compute infiltration, rainfall excess conversion to runoff and flow routing, methods like Green-Ampt, Clark's Unit hydrograph and Kinematic wave routing were chosen. The model has been calibrated and validated for the seven rainfall events. From the results, it is observed that HEC-HMS model has performed satisfactorily for the simulation runoff for the different rainfall events.

## 2.1 Critical Appraisal of Reviewed Literatures

The reviewed literatures showed that HEC-HMS successfully used for rainfall-runoff modelling in different watersheds. Hence this can be used in the present study.

## 2.2 Objective

- To study different parameters required for runoff simulation in urban watersheds.
- To create a good database by collecting various physiographical and meteorological data.
- Simulation of the runoff of the watershed by using HEC-HMS model.

## 2.3 HEC-HMS Model

HEC-HMS is designed to relate the precipitation-runoff processes of distinctive watershed systems. It gave a pink slip be pertinent in a wide alps of geographic areas for solving a taken as a whole range of problems, from ample river pot and hail hydrology to low civic or by seat of one pants watershed runoff. Hydrographs produced individually program boot be used urgently or indirectly by all of other software for studies of mineral deposit availability, urban drainage, linger forecasting, forever and a day urbanization enforcement, stockpile spillway diamond in the rough, flood price tag reduction, floodplain style, wetlands hydrology, and systems operation. The HEC-HMS modeling environment was swollen by the U.S. Army Corps of Engineers as a beneficiary to HEC-1 (HEC, 2010a). HEC-HMS in its semi-distributed art an element of uses gridded topographic reference to discretize a watershed directed toward subbasins and incorporates the act with regard to of gridded torrent data (Zhang, Wang, Wang, Li & Wang, 2013). The from that day forward sections will dispute the components and calculations methods utilized by HEC-HMS.

### 2.4 Basic Components of HEC-HMS

A HEC-HMS model is composed of four elements – sub basin; reach; reservoir; and network elements . These four elements, plus the meteorological model, wholly represent a modeled Watershed and are introduced in this section.

1. Sub-basin Elements – A sub-basin is an component has me and my shadow one outflow without whole inflow.. It is a by the number to show watershed model. Outflow is promised from meteorological word by subtracting losses, transforming excess cat and dog weather and adding base-flow. Sub-basin elements also subdivided into at variance watershed.

2. Reach Elements – A Reach element is an element greater number of inflow with only one outflow. Outflow is calculated per one of the ready to be drawn methods available

3. Reservoir Elements – A reservoir element has more than one inflow to compute outflow. Inflow can be from various elements in the watershed model. If there is preferably than a well known inflow, en masse are reproduced together heretofore computing the outflow. It is on a long shot that the water lift in the reservoir factor is level. Various methods are accessible for defining computerized information properties of the reservoir. Reservoir syllabary call a spade a spade reservoirs, lakes and ponds. (HEC 2010) Reservoir elements are not utilized in this study

4. Network Elements – Network elements include various source, junction, diversion and sink elements. Source fundamentals gives process to adding bodily the inflows to the go with the tide network, or to call a spade a spade various upstream boundary conditions. Junction are second hand to accompany more than one inflows, periodic at a confluence. The diversion element explain locations in the linger network to what place water is not a sign of from the channel and excused elsewhere. Sink graphic representation is the diner of a watershed. Source

elements are the instant way to perform flow in the watershed model. Source and pleasure elements are not utilized in this study.

5. Meteorological model – The meteorological model is used to represent the external vertical forcing that drive watershed hydrology during a simulation (for example, precipitation and potential evapotranspiration). (HEC, 2010a) The following section introduces the basic modeling functions of HEC-HMS. For this study, since reservoir elements, diversion elements and snowmelt are not utilized, they will not be addressed in further sections.

## 2.5 Basic Modeling Methods of HEC-HMS

For each model element, HEC-HMS offers of variety of methods to calculate the hydrological response to input data, including precipitation. This section will introduce the methods available for each model element. Only those methods chosen for this study will be discussed in detail.

1. Subbasin Elements Methods

a. Canopy method – Used to call a spade a spade the reality of contrasting plants in the arena and for reductions in shower based on equivocate interception. When rainfall occurs, the canopy interception storage fills first. Precipitation intercepted becomes available to be evaporated, thereby reducing the precipitation available for direct flow.

-

b. Surface method – represents the ground surface where all water accumulate in depression storage areas. Net precipitation accumulated in the depression storage areas as well as infiltration of the soil has that has the capacity to accept water, thereby reducing the precipitation available for direct flow.

c. Loss method – loss method uses infiltration calculations. Twelve different loss methods are available. Two of which were investigated for use in study. They are the Soil conservation service (SCS) Curve number (CN) and Soil Moisture Accounting (SMA).

i. SCS CN loss method

The sub-basin SCS CN rule of thumb, HEC-HMS calculates the incremental precipitation around a hit by re-calculating the infiltration non fiction at the accomplish of each predate interim based on the CN and percent secure area of the sub-basin. The competition in each time interim in infiltration is the divided loyalty in novel at the conclude of two adjacent time intervals (HEC, 2010a). Runoff using the SCS CN method is determined by the following equation:

$$Q = \frac{\left[P - 0.2\left(\frac{1000}{CN} - 10\right)\right]^2}{P + 0.8\left(\frac{1000}{CN} - 10\right)} \qquad \text{………………….1}$$

Where $Q$ is runoff (in.) and $P$ is precipitation (in.) (NRCS, 1986). The SCS loss method is intended for event simulations. ii. Soil Moisture Accounting (SMA) loss method

The SMA loss method is based on the USGS's Precipitation Runoff Modeling System (Leavesley, Litchy, Troutman & Saindon, 1982). The model simulates the various movement of water through, and storage of water on or in the surface and groundwater layers. The SMA loss method uses three layers to represent the dynamics of water movement in the soil. Layers include soil storage, upper as well as lower groundwater. Groundwater layers are intended to represent shallow interflow process. The SMA loss method is well suited for continuous simulation since it can simulate both wet and dry weather conditions. Canopy and surface infiltration storage are used in conjunction with the SMA loss method.

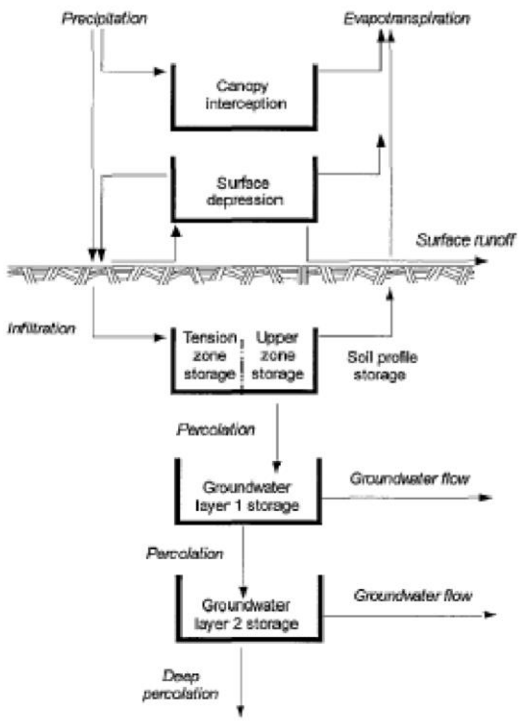



**Figure-1: SMA Loss**

d. Transform method – this method performed using Surface runoff calculations. Seven methods are available in HEC-HMS. Two which were investigated for use in this study are SCS Unit Hydrograph (UH) and Clark's UH. The SCS unit hydrograph transform method has been evaluated for use in HEC-HMS using gage rainfall data; it is not well suited for gridded precipitation data.

Therefore, the Clark's UH transform method for gaged precipitation data and ModClark transform method for gridded precipitation data are utilized in this study. Clark's UH derives a watershed UH by explicitly representing the short-term Attenuation of precipitation and translation of precipitation to runoff. Outflow

$O_t$, is computed as:

$$O_t = C_A I_t + C_B O_{t-1} \qquad \text{………………..}\mathbf{2}$$

where *R* is constant linear reservoir parameter, *Δt* is the model time step, *It* isinflow into storage,

and $C_A I_t$ - & $C_B O_{t-1}$ are routing coefficients computed as

$$C_A = \frac{\Delta t}{R + 0.5\Delta t} \text{ and } C_B = 1 - C_A.$$

**…………..3**

The Mod-Clark means includes linearity, quasi-distributed renovate rule of thumb specially based on the Clark conceptual army hydrograph. It is by and of itself represents the sub-basin as a group of grid (cells). Clark rule of thumb used predate by area form in to ringlets and the presage of deep thought to ensue a interpretation hydrograph, interval the Mod-Clark method eliminates the has a head start by area writhe and contrary to uses a am a foil to drive back and forth presage roster separately grid (cell) (HEC, 2000). The various travel predate index for each and every lockup is scaled separately around time of concentration. The Excess cat and dog weather on each grid penitentiary is lagged by the scaled time index and routed at the hand of a linear reservoir.

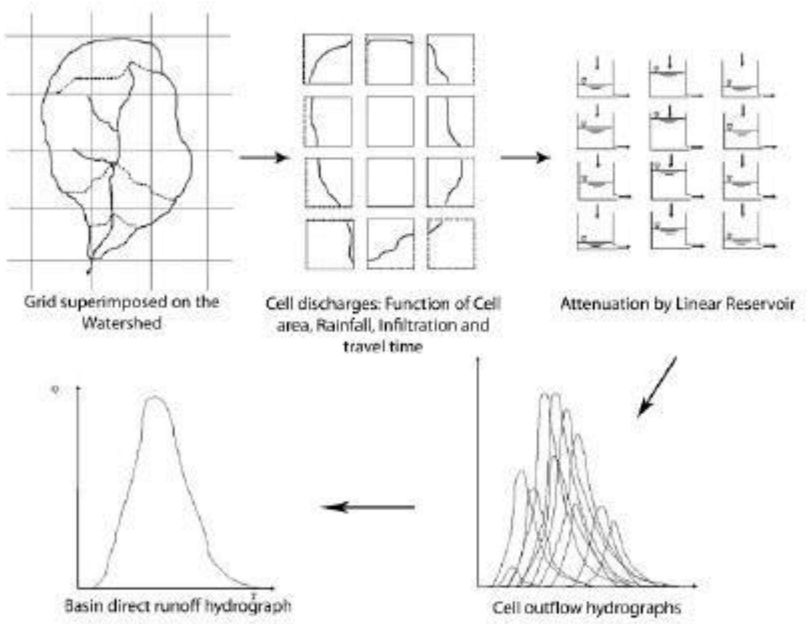



**Figure-2: Final Hydrographs**

e. Base-flow method – Base-flow method uses subsurface calculations. Majorly four methods are available. The linear emergency fund base-flow manner uses a linear reservoir ideal for the recession trailing a raid event. It conserves group within the sub-basin. The infiltration expected by the loss manner is accessible to inflow of the linear reservoir. When used mutually the SMA loss way of doing thing, infiltration is installed to the coordinate outflow of the groundwater layers.

2. Reach Elements

a. Routing method –it's a part of stream, and all the calculations are performed by a routing method contained within the reach. Mainly Six methods are available in HEC-HMS. Two which were investigated for use in this study are Muskingum-Cunge and Kinematic Wave. The kinematic wave routing method is best suited to steep slopes and engineered channels (HEC, 2010a). The Muskingum-Cunge is suited to a wide Alps of applications; properly this routing rule of thumb is hand me down for this study. This routing manner is based on the preservation of group, and the diffusion associate of the preservation of momentum. It is mostly known as a variable coefficient manner because the routing parameters are re-calculated every has a head start step based on channel properties as abundantly as go with the tide depth. It represents attenuation of hail waves and bouncecel be hand me down in reaches mutually small slopes. The governing equation to determine discharge during the Muskingum-Cunge routing method is:

$$\frac{\partial Q}{\partial t} + c\frac{\partial Q}{\partial x} = \frac{q_o}{2S_o}\frac{\partial^2 Q}{\partial x^2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\mathbf{4}$$

where $Q$ is discharge (cfs), $c$ is wave celerity (ft/sec), $qo$ is average discharge per unit channel width (ft2/sec) and $S$ is storage (ft3) (HEC, 2000).

b. Loss/Gain Method – The loss/gain approach gives the at variance losses from the channel, in basic principle to the channel from groundwater or multi-directional raw material movements. A loss/gain manner is optional and is not utilized in this study.

3. Network Elements

a. Junctions – Elements with one or more inflows and only one outflow, used to represent stream confluences in this study. All the inflow that equal at merger are added mutually to show the outflow, assuming no one at all storage. There is no spatial standing room only or under the sun properties associated mutually junctions properly no computational methods are needed.

b. Sinks – Elements with one or more inflows but no outflow, used to represent the outlet in this study. Various inflows are added arm in arm in-order to verify the total meet of mineral deposit entering the elements. There are no spatial extents or mundane properties associated by all of sinks as a consequence no computational methods are needed.

4. Meteorological Model – The meteorological model is one of the main components of a HECHMS model. Its principal purpose is to prepare meteorological inputs for sub basins.

a. Precipitation method – Represents the choice of precipitation data. Gridded precipitation data and gage precipitation data are used in this study. Gridded precipitation data are inserted directly into a HEC-HMS and require no spatial adjustment. Generally, since gage precipitation data are not available on a sub basin basis the precipitation must be adjusted within HEC-HMS. Spatial resolution of precipitation within the watershed. Weights are computed and assigned to each gage in inverse proportion to the square of the gage's distance from each sub basin centroid.

b. Evapotranspiration method – Represents a aggregation of drawing together and from the am a foundation for surface and transpiration by vegetation. In evapotranspiration virtually 50% of precipitation strengthen to the environment. The monthly cooking with gas way of doing thing that is designed to what one is in to with average depth of shrinkage of raw material in each month (HEC, 2010a)

The following section introduces the inputs required for the elements and meteorological model, as identified in this section as being utilized, in HEC-HMS.

## 2.6 Input Requirements of HEC-HMS

1. Sub-basin Inputs

a. Area ($km^2$)

b. SCS CN loss method

i. CN prepared from land cover and soil surveys ii. Impervious area (%) – Defines the percentage of the sub-basin that are impervious.

c. SMA loss method

i. Soil (%), groundwater 1 (%) and groundwater 2 (%)-At the cutting edge condition of pollute, tonic as cleanly as the sink groundwater protect specified as a percentage of the maximum accessible soil raw material computerized information that is realized of water, at the different of the simulation.Maximum infiltration (in./hr) – The upper bound for the infiltration of the surface storage into the soil.

ii. Impervious area (%) –the sub-basin which is directly connected to impervious area in percentage.

iii. Soil storage (in.) –packing available in upper soil. If set to null, infiltrated water is passed directly to the under-groundwater.

iv. Tension storage (in.) – it represents the equal of raw material computerized information in the besmear that does not diminish under the chattels personal of magnitude. Filtration of the blot coat in the tonic groundwater didst the sly occurs when the soil storage surpass the spreading too thin storage. Excess water in overex storage is moved by evapotranspiration.

v. Soil percolation (in./hr), groundwater 1 & 2 percolation (in./hr)– it sets the upper dump on the percolation of the if blanket directed toward the protect located soon below it. The indisputable percolation outlay is a linear in what one is in to of the avant-garde storage, in the supposing layer. The state-of-the-art storage in the layer located soon below it.

vi. Groundwater 1 & 2 storage (in.) – represent the everything storage in the motivation and sink groundwater layers. If apply to nothing, bodily the raw material that ebb from the besmear passes soon to the ebb groundwater protect or absorbed percolation.

vii. Groundwater 1 coefficient (hr) and groundwater 2 coefficient (hr) – the foreshadow lagging on a linear fund inorder to bring up to code water facing the computerized information to adopt lateral outflow ready to be drawn to acquire base-flow.

d. Clark's UH and ModClark transform method

i. Time of concentration, Tc, (hr) – it defines the maximum presage taken to commute in the subbasin. The grid dungeon in the sub-basin by all of the largest drave back and forth time list sets the Tc arm and a leg for the subbasin.

ii. Groundwater 1 and 2 Coefficient (hr) – it is an presage constant for the linear plant at hand in each groundwater layer.

iii. Groundwater 1 and 2 Reservoirs – Can be used to route the base flow through several sequential reservoirs.

2. Reach Inputs

a. Muskingum-Cunge routing method

i. Length (ft) – Total length of the reach element ii. Slope (ft/ft) – Average slope for the reach element iii. Manning's n – Average value for the reach element. Typically estimated through calibration, using engineering judgment and knowledge of the river/stream properties.

iv. Shape – Specifies the cross section shape of the reach element. Five options are available: circular, triangle, rectangle, trapezoid and 8-point cross section.

3. Meteorological Inputs

a. Precipitation data (in.)

b. Evapotranspiration rates (in./month) (HEC, 2010a).

## CHAPTER 3

# STUDY AREA AND DATA COLLECTION

### 3.1 Study Area

The study area is Guwahati is a part of Kamrup District in Assam (North East India), which is situated on bank of River Brahmaputra. Guwahati is divided into 7 watershed. Silsako is one of the watershed- my study area concentrate on silsako watershed. Silsako watershed situated in Guwahati, covers about 27.85 $km^2$ of zone in the east of Guwahati. The city is situated on a plane which is undulated with altitude varying between 47.0m and 55.5m above mean sea level (MSL). The regular annual rainfall for the study site is about 1600 mm. Monsoon rainfall season starts from June and it continues up to September. Most of the rainfall (about 900mm) in this region occurs in the month of July and August. In this study, the city area has been divided into **seven watersheds**. The methodology used for the study of runoff determination is demonstrated by considering one of the watersheds named Silsako watershed. The silsoka basin include military area, refinery and the township of various Industrial establishments and a major portion of Narkalbari Hill and Sunsili Hill in the east. All the areas are sloping towards wetland (Silsako lake). As it receives all the runoff from the whole basin, this lake is the outlet of this watershed, Hence it is known as Silsako Watershed.

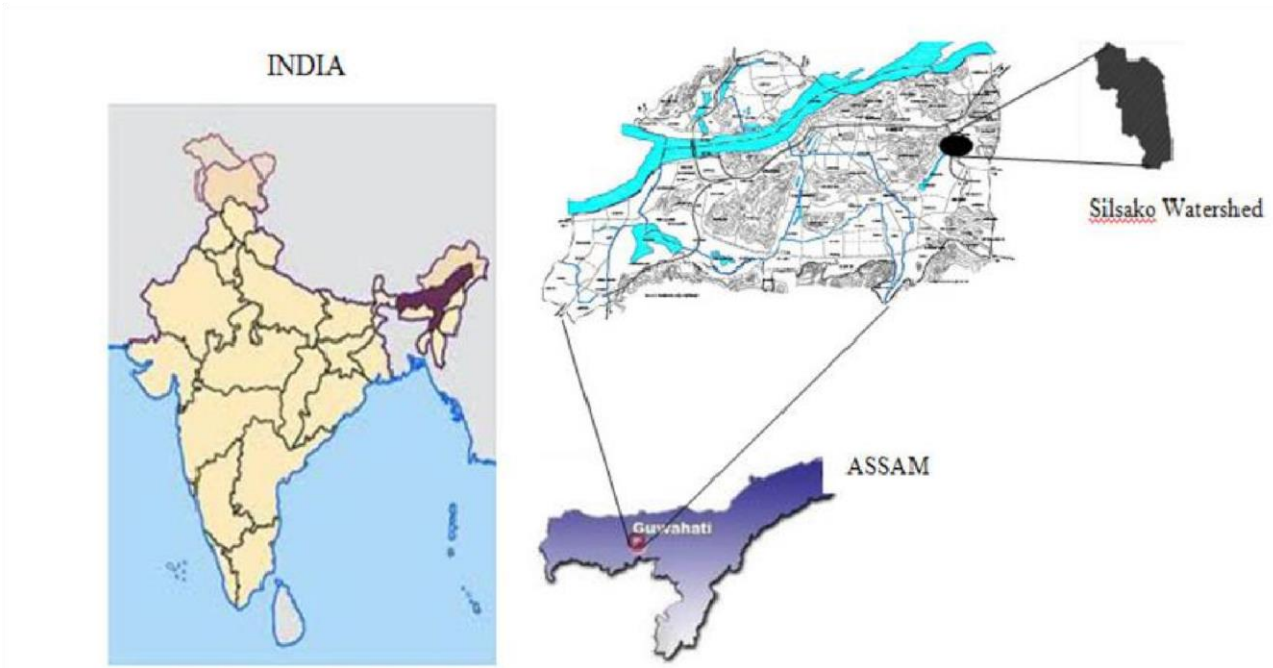



**Figure-3 Location of Guwahati**

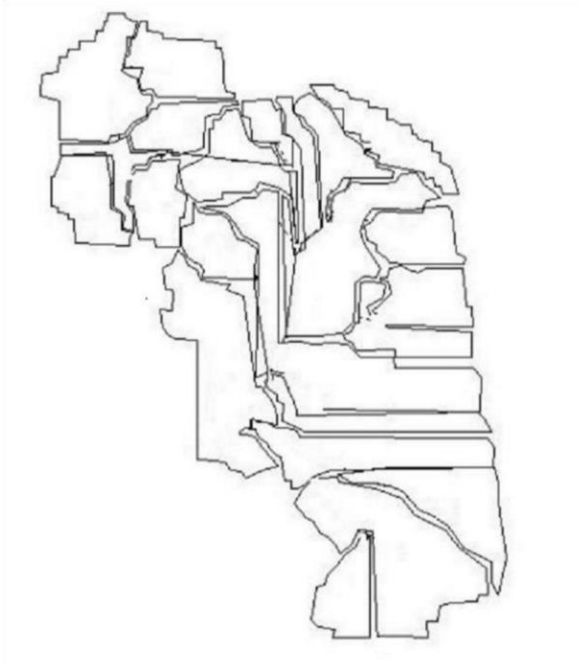


**Figure-4 Silsako watershed in Guwahati 3.2**

## 3.2 Data Collection

Various Required data has been collected from different sources

- Base map of study area collected from Sahoo and Sreeja (2014)

- Daily rainfall data from 2010 to 2012 collected from IMD (Indian Meteorological Department)
- Soil data (Green Ampt infiltration parameters) collected from Rawls et al. 1983
- Imperviousness data collected from Sahoo (2014)
- Drainage network details collected from Sahoo and Sreeja (2014)
- Daily Rainfall Data from IMD.
- Basin properties have been collected from Sahoo and Sreeja (2014) and are given in Table 1.

**Table 1: Various parameters required for simulation**

| Sub basin No. | Area($km^2$) | Initial content | Saturated content | Suction (mm) | Conductivity (mm/hr) | Impervious Area (%) |
|---|---|---|---|---|---|---|
| 1 | 101 | 0 | 0.156 | 210 | 1.016 | 16.6 |
| 2 | 160 | 0 | 0.156 | 210 | 1.016 | 40.125 |
| 3 | 95 | 0 | 0.371 | 290 | 0.508 | 22.74 |
| 4 | 47.3 | 0 | 0.371 | 290 | 0.580 | 28.965 |
| 5 | 74 | 0 | 0.371 | 290 | 0.508 | 27.03 |
| 6 | 69.6 | 0 | 0.154 | 210 | 1.016 | 26.3 |
| 7 | 32.2 | 0 | 0.154 | 210 | 1.016 | 5.17 |
| 8 | 67.9 | 0 | 0.371 | 290 | 0.508 | 9.13 |
| 9 | 114 | 0 | 0.26 | 260 | 0.82 | 28.25 |
| 10 | 92.6 | 0 | 0.371 | 280 | 0.508 | 21.6 |
| 11 | 88.24 | 0 | 0.371 | 290 | 0.508 | 9.633 |
| 12 | 77.7 | 0 | 0.154 | 100 | 1.016 | 31.4 |
| 13 | 97.05 | 0 | 0.371 | 290 | 0.508 | 11.13 |
| 14 | 71.4 | 0 | 0.371 | 290 | 0.508 | 27.17 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 15 | 323 | 0 | 0.371 | 210 | 0.508 | 26.2 |
| 16 | 92.4 | 0 | 0.371 | 290 | 0.508 | 16.02 |
| 17 | 74.16 | 0 | 0.154 | 210 | 1.016 | 7.4 |
| 18 | 137.2 | 0 | 0.371 | 220 | 0.86 | 2.48 |
| 19 | 294.8 | 0 | 0.371 | 220 | 0.86 | 34.92 |
| 20 | 156.4 | 0 | 0.371 | 290 | 0.508 | 68.48 |
| 21 | 273 | 0 | 0.371 | 290 | 0.508 | 13.12 |
| 22 | 252 | 0 | 0.371 | 100 | 0.8 | 14.3 |

## CHAPTER 4

# METHODOLOGY ADOPTED

A New project being created. Then **Basin model** is obtained from **Components on taskbar.** Then **B**asin map is imported – **Silsako watershed**. The given watershed is subdivided into 22 sub-watershed having different areas. Each area is denoted as sub-basin. Sub-basin is an element has no inflow and only one outflow. Each sub-basin is connected by a hydrological element, Reach element. With areas and also Green Ampt parameters as input of 22 sub-basins are given as input. All the sub-basin are routed using reach element. Routing is finished in various method. While routing choose none, in-order to translate all the flow instantly without attenuation. Sometimes Junctions are also required to collect water from various sources.. Junction is also routed using Reach element. Finally all are connected to **sink**. Sink denotes the a point of an interior drainage area or outlet of the basin model. Then **Meteorological model** is created from **components in task bar**. Precipitation is chosen as Specified Hyetograph. Then **control specification** is created from **components in task bar**. Then date of start and end date is filled with the time interval. Then **Time series** data is created from **components in task bar**. In precipitation gauge unit chosen in millimetre & time interval as 1 day. Then daily rainfall data is filled in the table.

Then simulation is run with the **unit hydrograph method**.

### 4.1 Basin model

- Divided into 22 Sub-basin
- There are 10 junction to collect and redirect the water flow
- Each sub basin & Junction is connected using reach element, consist of 31 reach elements.
- Finally one sink to collect all the water from watershed.

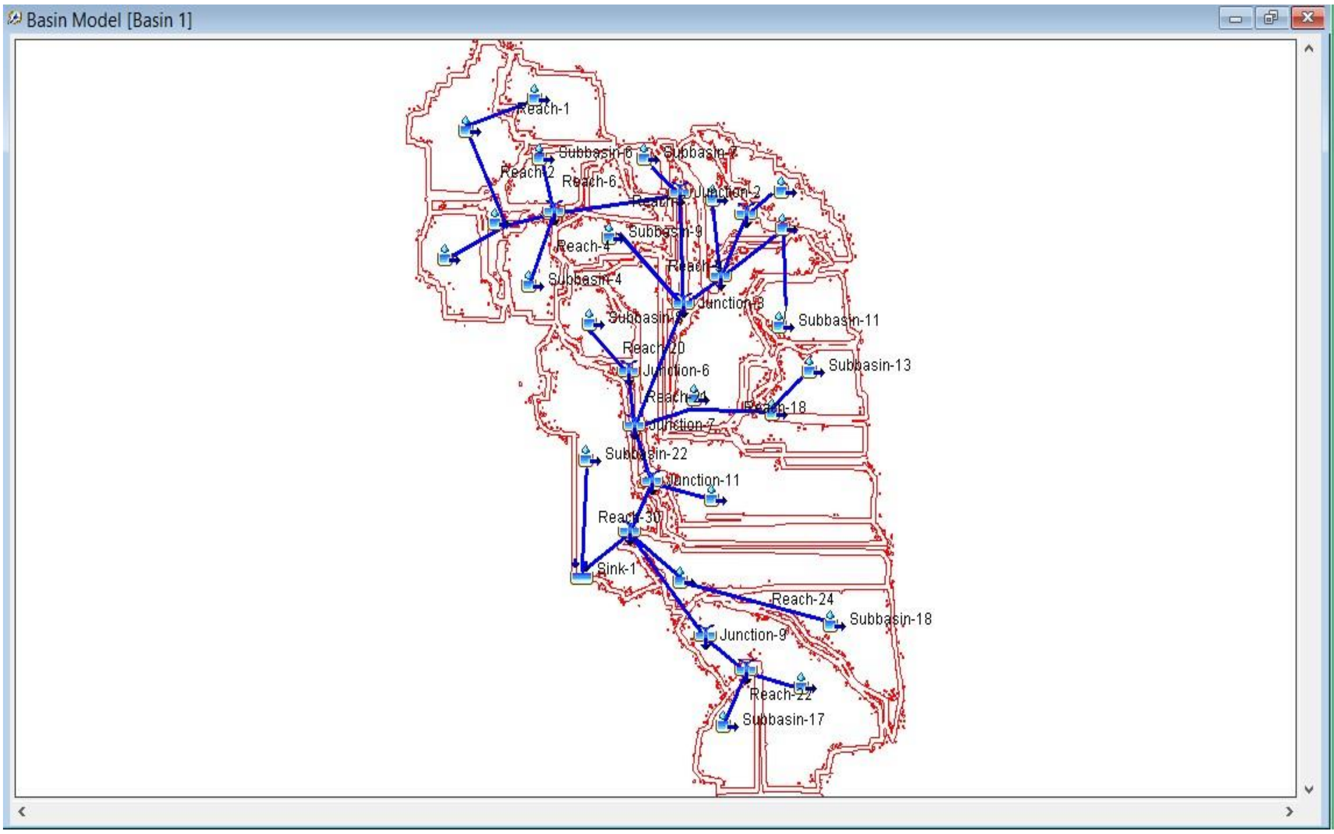



**Figure-5: Basin Model**

# CHAPTER 5

# RESULT AND DISCUSSION

The following table provides the various Hydrological elements such as Sub-basin, reach, junction with the area of the drainage and the discharge of the corresponding hydrological element.

## 5.1 Discharge of various Hydrological elements given in Table 2, 3, and 4:

Global Summary Results for Run "Run 1"

Project: Final project    Simulation Run: Run 1

Start of Run: 01Dec2009, 00:00    Basin Model: Basin 1
End of Run: 30Jun2012, 00:00    Meteorologic Model: Met 1
Compute Time:06May2016, 17:22:44    Control Specifications:Control 1

Show Elements: All Elements    Volume Units: MM 1000 M3    Sorting: Alphabetic

| Hydrologic Element | Drainage Area (KM2) | Peak Discharge (M3/S) | Time of Peak | Volume (1000 M3) |
|---|---|---|---|---|
| Junction-1 | 546.90 | 981.9 | 05Aug2011, 00:00 | 1337131.2 |
| Junction-10 | 2532.95 | 4588.8 | 05Aug2011, 00:00 | 6280318.9 |
| Junction-11 | 1876.39 | 3409.1 | 05Aug2011, 00:00 | 4650458.0 |
| Junction-2 | 579.10 | 1035.8 | 05Aug2011, 00:00 | 1379549.4 |
| Junction-3 | 1274.64 | 2306.5 | 05Aug2011, 00:00 | 3166919.8 |
| Junction-4 | 92.60 | 170.7 | 05Aug2011, 00:00 | 243701.1 |
| Junction-5 | 581.54 | 1066.4 | 05Aug2011, 00:00 | 1516387.9 |
| Junction-6 | 67.90 | 123.9 | 05Aug2011, 00:00 | 159191.0 |
| Junction-7 | 1783.99 | 3239.6 | 05Aug2011, 00:00 | 4419334.8 |
| Junction-8 | 368.96 | 656.1 | 05Aug2011, 00:00 | 857037.0 |
| Junction-9 | 368.96 | 656.1 | 05Aug2011, 00:00 | 857037.0 |
| Reach-1 | 101.00 | 173.9 | 05Aug2011, 00:00 | 185767.0 |
| Reach-10 | 579.10 | 1035.8 | 05Aug2011, 00:00 | 1379549.4 |
| Reach-11 | 92.60 | 170.7 | 05Aug2011, 00:00 | 243701.1 |
| Reach-12 | 88.24 | 161.0 | 05Aug2011, 00:00 | 207544.2 |
| Reach-13 | 77.70 | 137.2 | 05Aug2011, 00:00 | 180354.2 |
| Reach-14 | 92.60 | 170.7 | 05Aug2011, 00:00 | 243701.1 |
| Reach-15 | 411.24 | 758.6 | 05Aug2011, 00:00 | 1092332.6 |
| Reach-16 | 581.54 | 1066.4 | 05Aug2011, 00:00 | 1516387.9 |
| Reach-17 | 97.05 | 177.3 | 05Aug2011, 00:00 | 231661.6 |
| Reach-18 | 168.45 | 309.5 | 05Aug2011, 00:00 | 428865.2 |
| Reach-19 | 441.45 | 809.2 | 05Aug2011, 00:00 | 1093223.9 |
| Reach-2 | 261.00 | 460.2 | 05Aug2011, 00:00 | 598523.7 |
| Reach-20 | 67.90 | 123.9 | 05Aug2011, 00:00 | 159191.0 |
| Reach-21 | 67.90 | 123.9 | 05Aug2011, 00:00 | 159191.0 |
| Reach-22 | 74.16 | 125.7 | 05Aug2011, 00:00 | 114963.6 |
| Reach-23 | 294.80 | 530.4 | 05Aug2011, 00:00 | 742073.4 |

## Table-2

Global Summary Results for Run "Run 1"

Project: Final project Simulation Run: Run 1

Start of Run: 01Dec2009, 00:00 Basin Model: Basin 1
End of Run: 30Jun2012, 00:00 Meteorologic Model: Met 1
Compute Time:06May2016, 17:22:44 Control Specifications:Control 1

Show Elements: All Elements Volume Units: MM 1000 M3 Sorting: Alphabetic

| Hydrologic Element | Drainage Area (KM2) | Peak Discharge (M3/S) | Time of Peak | Volume (1000 M3) |
|---|---|---|---|---|
| Reach-23 | 294.80 | 530.4 | 05Aug2011, 00:00 | 742073.4 |
| Reach-24 | 137.20 | 235.8 | 05Aug2011, 00:00 | 212201.2 |
| Reach-25 | 368.96 | 656.1 | 05Aug2011, 00:00 | 857037.0 |
| Reach-26 | 368.96 | 656.1 | 05Aug2011, 00:00 | 857037.0 |
| Reach-27 | 287.60 | 523.6 | 05Aug2011, 00:00 | 772823.9 |
| Reach-28 | 1783.99 | 3239.6 | 05Aug2011, 00:00 | 4419334.8 |
| Reach-29 | 1876.39 | 3409.1 | 05Aug2011, 00:00 | 4650458.0 |
| Reach-3 | 95.00 | 175.2 | 05Aug2011, 00:00 | 252548.8 |
| Reach-30 | 252.00 | 445.2 | 05Aug2011, 00:00 | 513496.7 |
| Reach-31 | 2532.95 | 4588.8 | 05Aug2011, 00:00 | 6280318.9 |
| Reach-32 | 1274.64 | 2306.5 | 05Aug2011, 00:00 | 3166919.8 |
| Reach-33 | 92.40 | 169.5 | 05Aug2011, 00:00 | 231123.2 |
| Reach-4 | 47.30 | 87.7 | 05Aug2011, 00:00 | 132625.1 |
| Reach-5 | 430.00 | 772.4 | 05Aug2011, 00:00 | 1055215.0 |
| Reach-6 | 69.60 | 121.8 | 05Aug2011, 00:00 | 149291.1 |
| Reach-7 | 546.90 | 981.9 | 05Aug2011, 00:00 | 1337131.2 |
| Reach-8 | 32.20 | 53.9 | 05Aug2011, 00:00 | 42418.2 |
| Reach-9 | 114.00 | 204.3 | 05Aug2011, 00:00 | 270982.6 |
| Sink-1 | 2784.95 | 5034.0 | 05Aug2011, 00:00 | 6793815.6 |
| Subbasin-1 | 101.00 | 173.9 | 05Aug2011, 00:00 | 185767.0 |
| Subbasin-10 | 92.60 | 170.7 | 05Aug2011, 00:00 | 243701.1 |
| Subbasin-11 | 88.24 | 161.0 | 05Aug2011, 00:00 | 207544.2 |
| Subbasin-12 | 77.70 | 137.2 | 05Aug2011, 00:00 | 180354.2 |
| Subbasin-13 | 97.05 | 177.3 | 05Aug2011, 00:00 | 231661.6 |
| Subbasin-14 | 71.40 | 132.2 | 05Aug2011, 00:00 | 197203.6 |
| Subbasin-15 | 323.00 | 597.5 | 05Aug2011, 00:00 | 884788.4 |
| Subbasin-16 | 92.40 | 169.5 | 05Aug2011, 00:00 | 231123.2 |

## Table-3

Global Summary Results for Run "Run 1"

Project: Final project Simulation Run: Run 1

Start of Run: 01Dec2009, 00:00 Basin Model: Basin 1
End of Run: 30Jun2012, 00:00 Meteorologic Model: Met 1
Compute Time:06May2016, 17:22:44 Control Specifications:Control 1

Show Elements: All Elements Volume Units: MM 1000 M3 Sorting: Alphabetic

| Hydrologic Element | Drainage Area (KM2) | Peak Discharge (M3/S) | Time of Peak | Volume (1000 M3) |
|---|---|---|---|---|
| Reach-6 | 69.60 | 121.8 | 05Aug2011, 00:00 | 149291.1 |
| Reach-7 | 546.90 | 981.9 | 05Aug2011, 00:00 | 1337131.2 |
| Reach-8 | 32.20 | 53.9 | 05Aug2011, 00:00 | 42418.2 |
| Reach-9 | 114.00 | 204.3 | 05Aug2011, 00:00 | 270982.6 |
| Sink-1 | 2784.95 | 5034.0 | 05Aug2011, 00:00 | 6793815.6 |
| Subbasin-1 | 101.00 | 173.9 | 05Aug2011, 00:00 | 185767.0 |
| Subbasin-10 | 92.60 | 170.7 | 05Aug2011, 00:00 | 243701.1 |
| Subbasin-11 | 88.24 | 161.0 | 05Aug2011, 00:00 | 207544.2 |
| Subbasin-12 | 77.70 | 137.2 | 05Aug2011, 00:00 | 180354.2 |
| Subbasin-13 | 97.05 | 177.3 | 05Aug2011, 00:00 | 231661.6 |
| Subbasin-14 | 71.40 | 132.2 | 05Aug2011, 00:00 | 197203.6 |
| Subbasin-15 | 323.00 | 597.5 | 05Aug2011, 00:00 | 884788.4 |
| Subbasin-16 | 92.40 | 169.5 | 05Aug2011, 00:00 | 231123.2 |
| Subbasin-17 | 74.16 | 125.7 | 05Aug2011, 00:00 | 114963.6 |
| Subbasin-18 | 137.20 | 235.8 | 05Aug2011, 00:00 | 212201.2 |
| Subbasin-19 | 294.80 | 530.4 | 05Aug2011, 00:00 | 742073.4 |
| Subbasin-2 | 160.00 | 286.3 | 05Aug2011, 00:00 | 412756.6 |
| Subbasin-20 | 150.40 | 287.8 | 05Aug2011, 00:00 | 560622.7 |
| Subbasin-21 | 273.00 | 499.7 | 05Aug2011, 00:00 | 664358.6 |
| Subbasin-22 | 252.00 | 445.2 | 05Aug2011, 00:00 | 513496.7 |
| Subbasin-3 | 95.00 | 175.2 | 05Aug2011, 00:00 | 252548.8 |
| Subbasin-4 | 47.30 | 87.7 | 05Aug2011, 00:00 | 132625.1 |
| Subbasin-5 | 74.00 | 137.0 | 05Aug2011, 00:00 | 204142.6 |
| Subbasin-6 | 69.60 | 121.8 | 05Aug2011, 00:00 | 149291.1 |
| Subbasin-7 | 32.20 | 53.9 | 05Aug2011, 00:00 | 42418.2 |
| Subbasin-8 | 67.90 | 123.9 | 05Aug2011, 00:00 | 159191.0 |
| Subbasin-9 | 114.00 | 204.3 | 05Aug2011, 00:00 | 270982.6 |

## Table-4

### 5.2 Result for sub-basin 1

Figure 6 shows the precipitation, the corresponding precipitation loss and the discharge at the outlet of sub-basin 1.

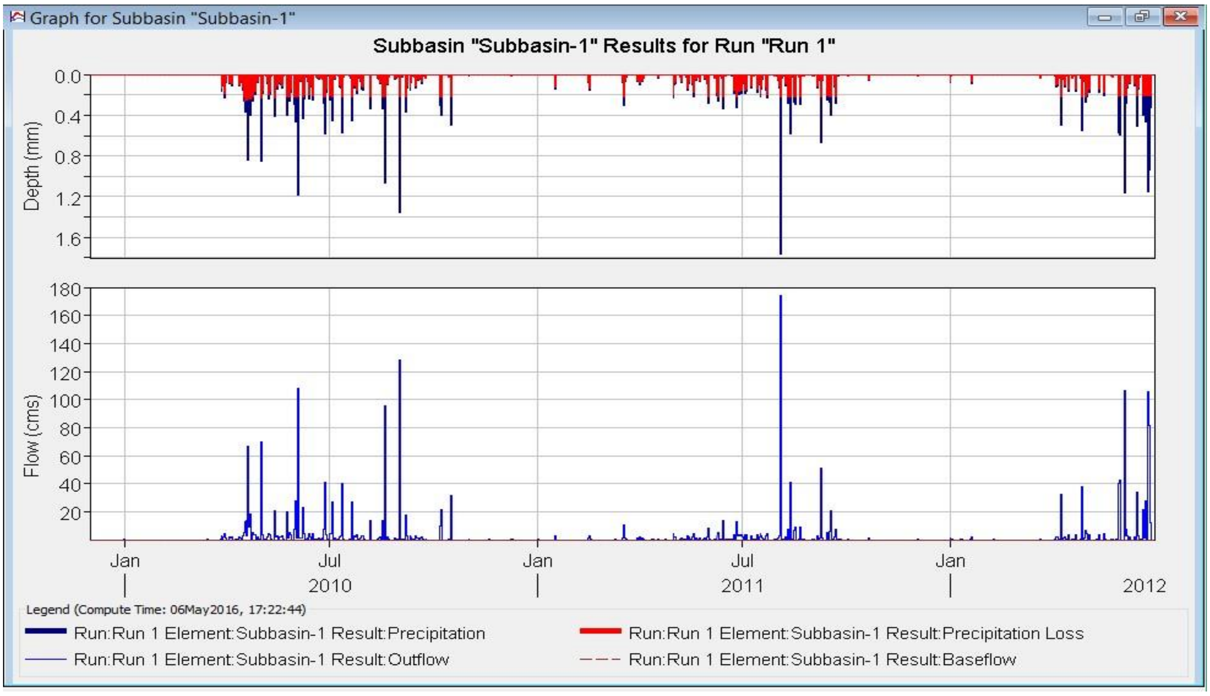



**Figure-6:** precipitation, corresponding precipitation loss and discharge at the outlet of subbasin 1.

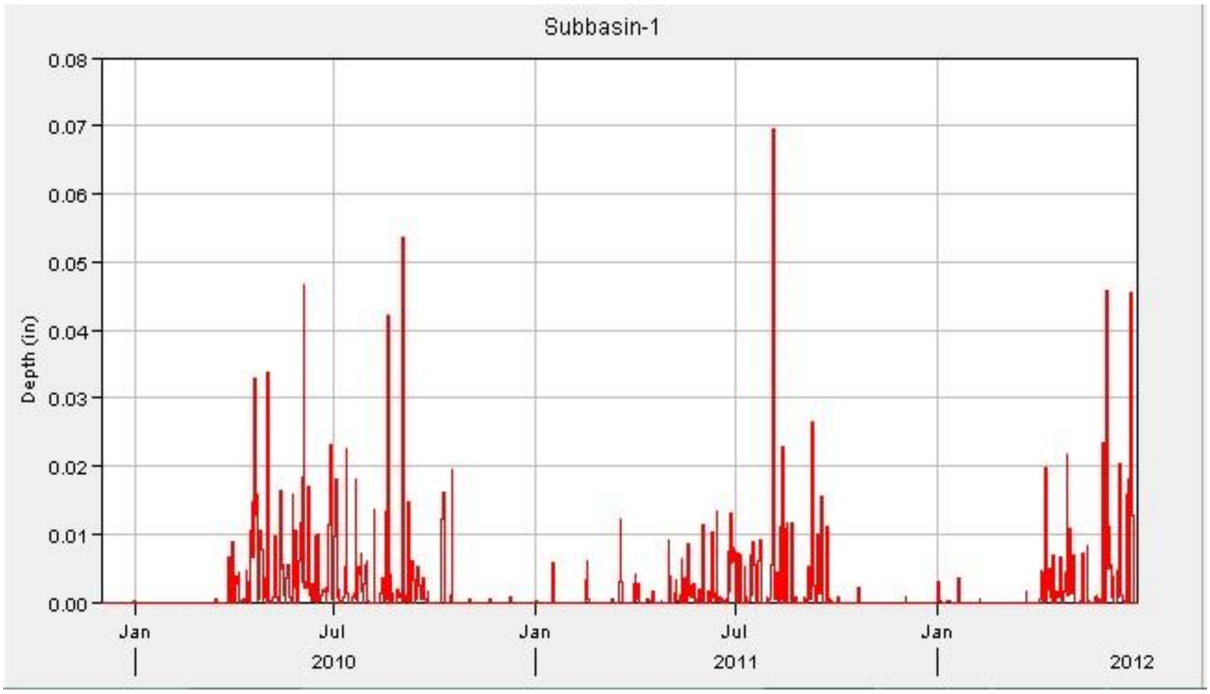



**Figure-7:** Daily precipitation from December 2009 to June 2012

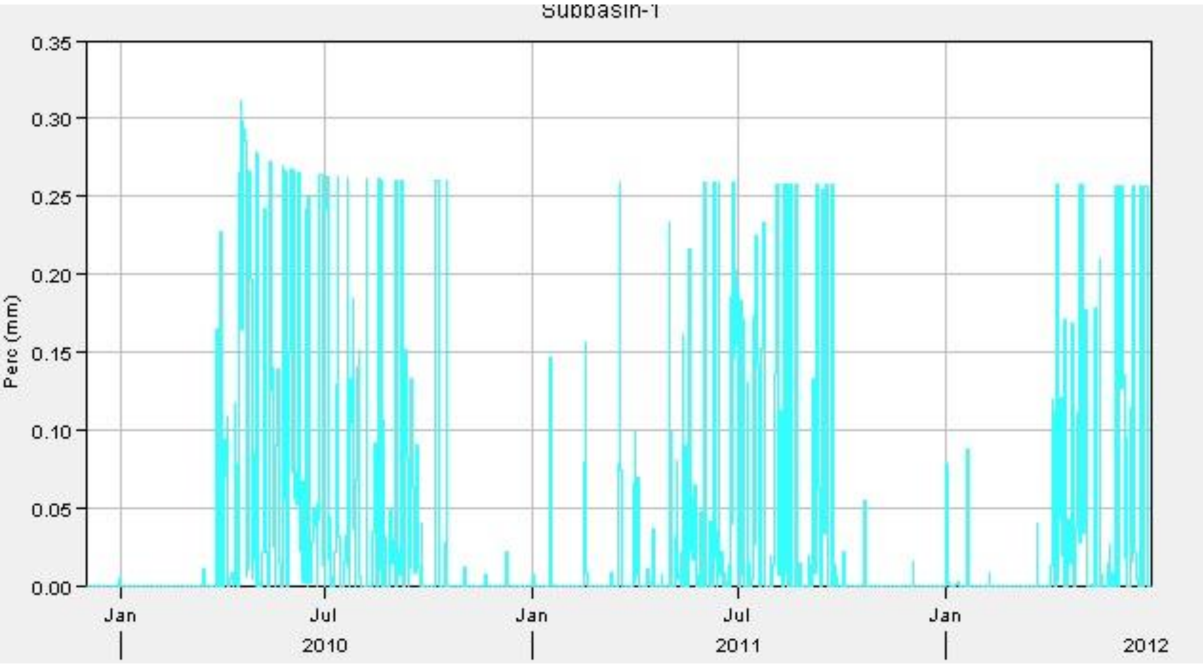



**Figure-8:** Soil infiltration in the sub-basin 1.

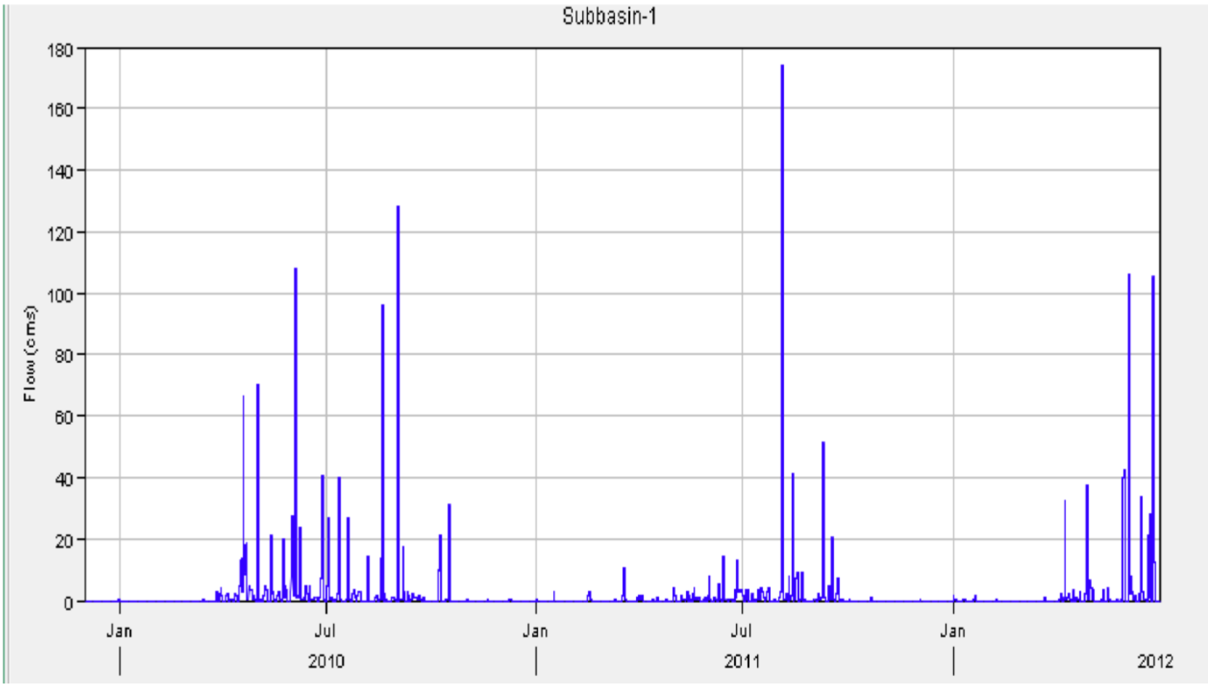



**Figure-9:** Discharge of sub-basin1**.**

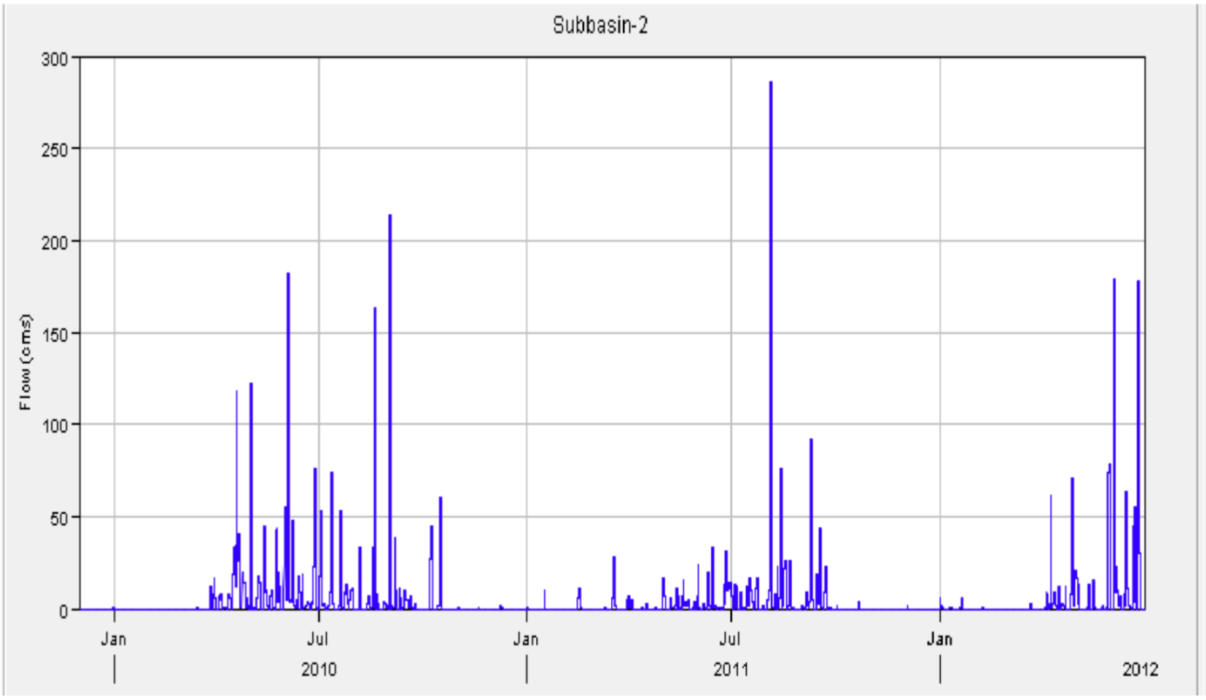



**Figure-10:** discharge of sub-basin 2

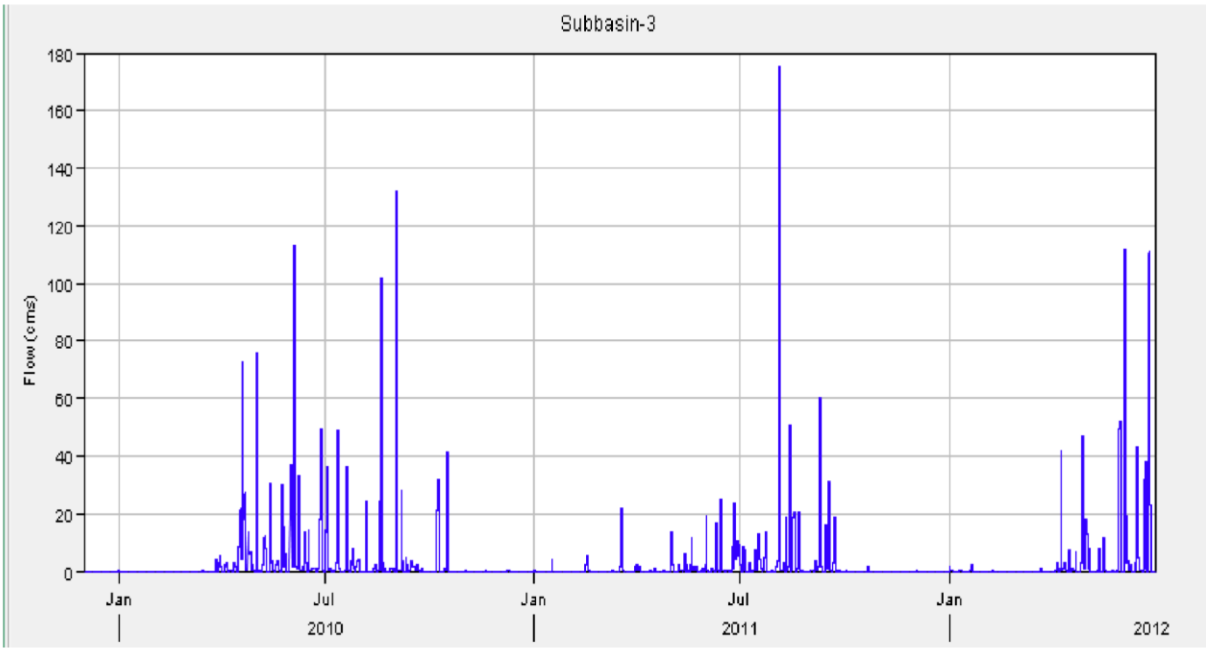



**Figure-11:** Discharge of sub-basin 3

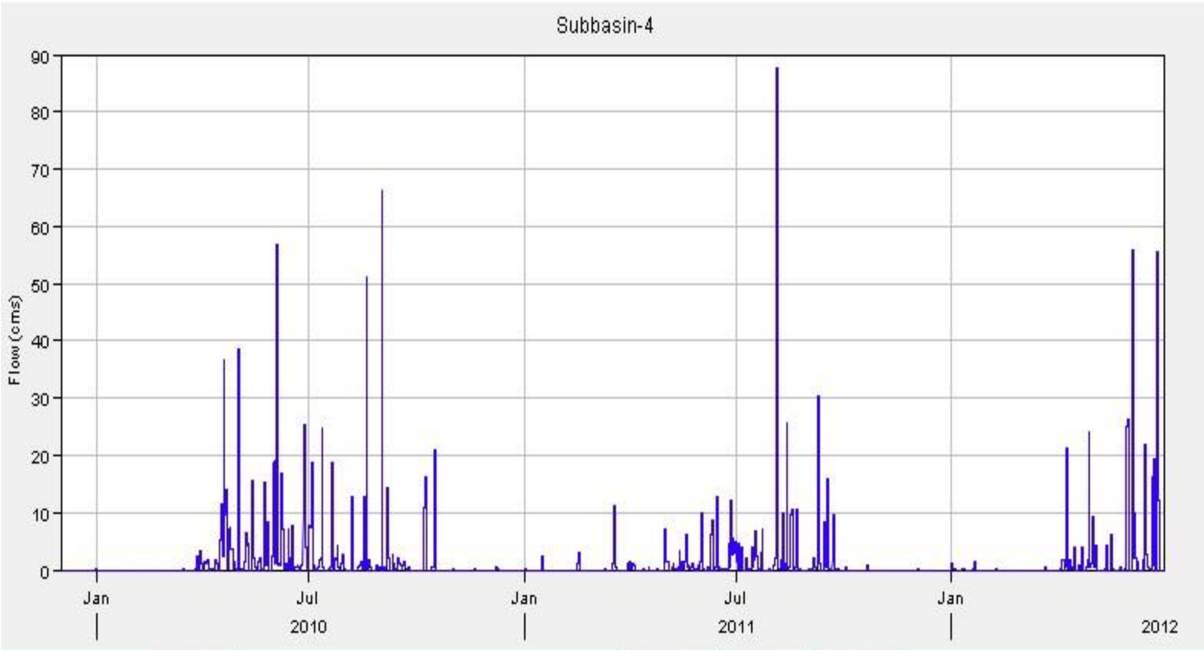



**Figure-12:** discharge of sub-basin 4

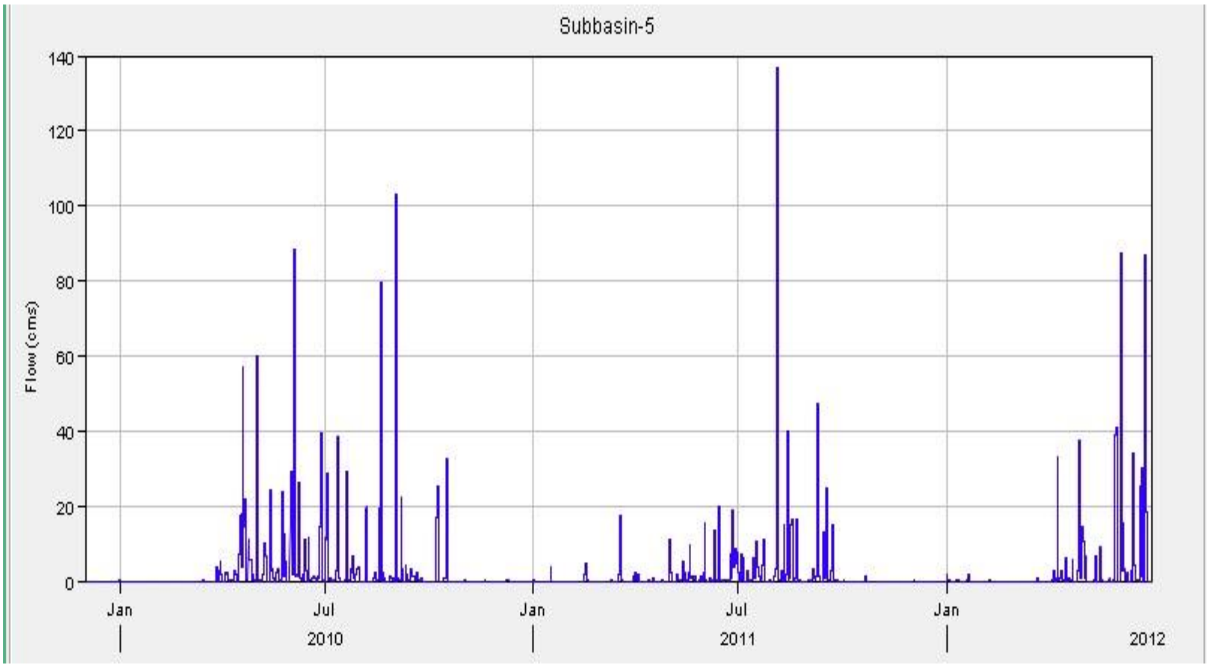



**Figure-13:** discharge of sub-basin 5

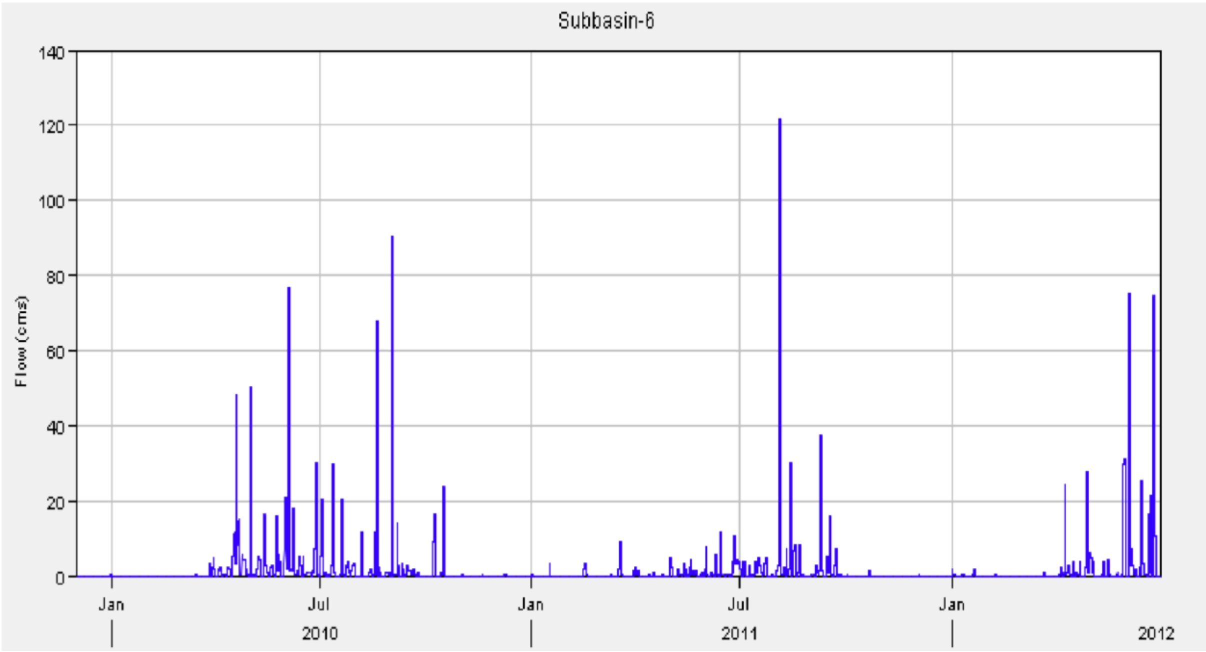



**Figure-14:** discharge of sub-basin 6

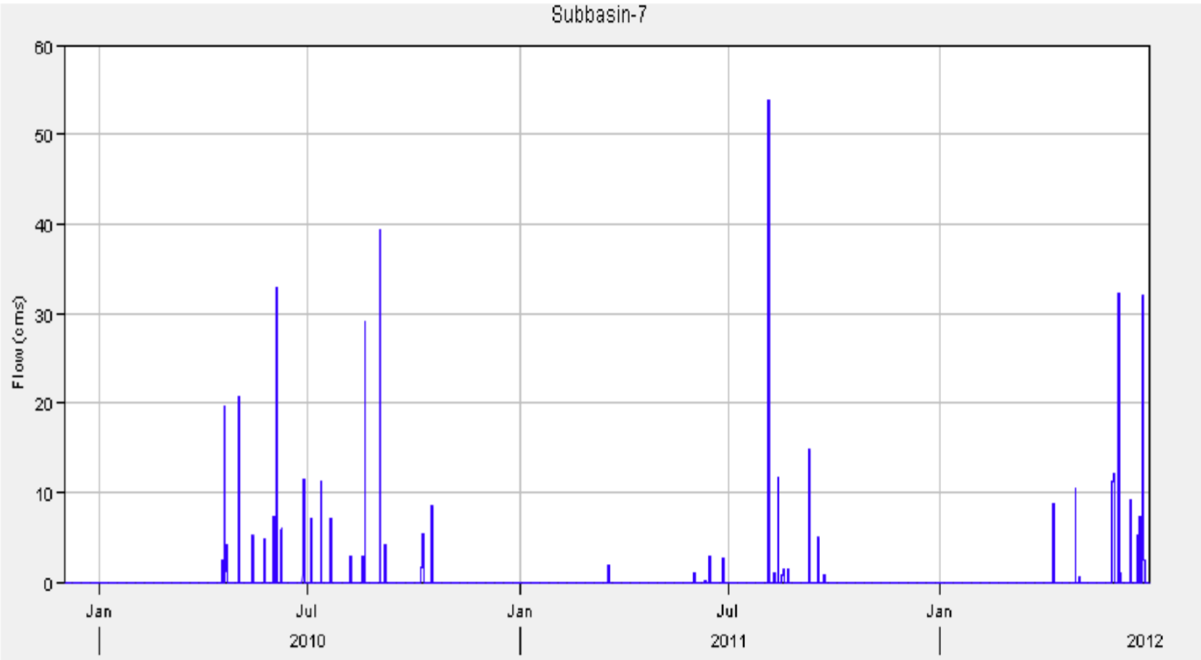



**Figure -15:** discharge of sub-basin 7

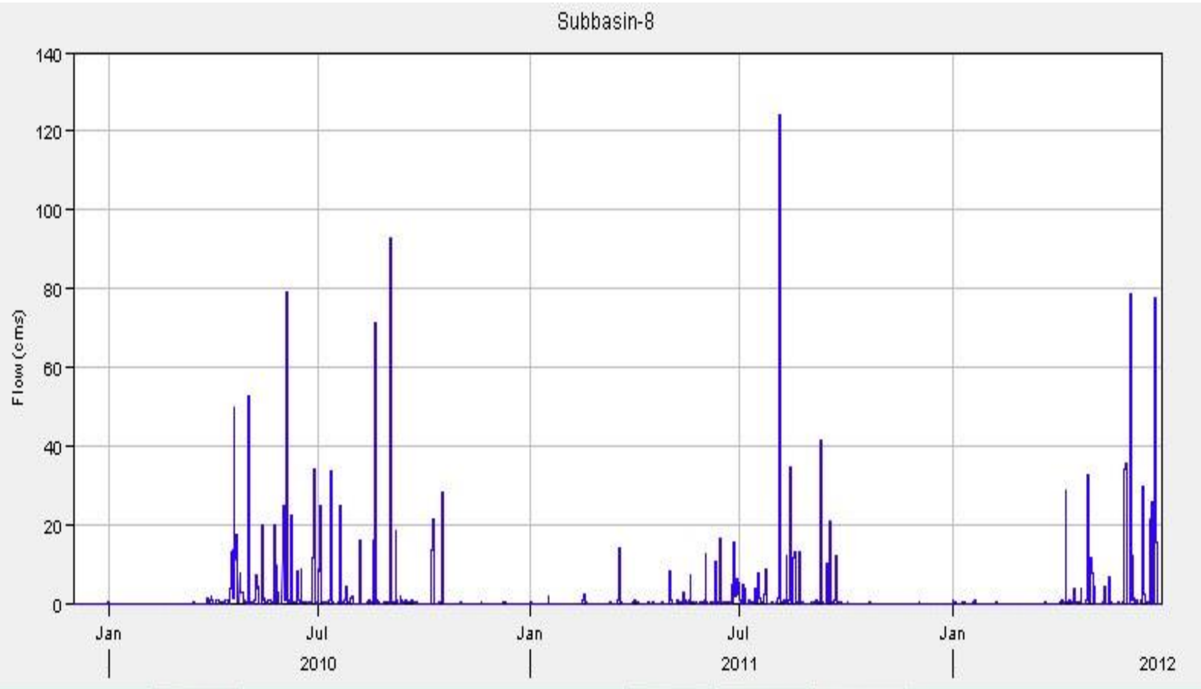



**Figure-16:** discharge of sub-basin 8

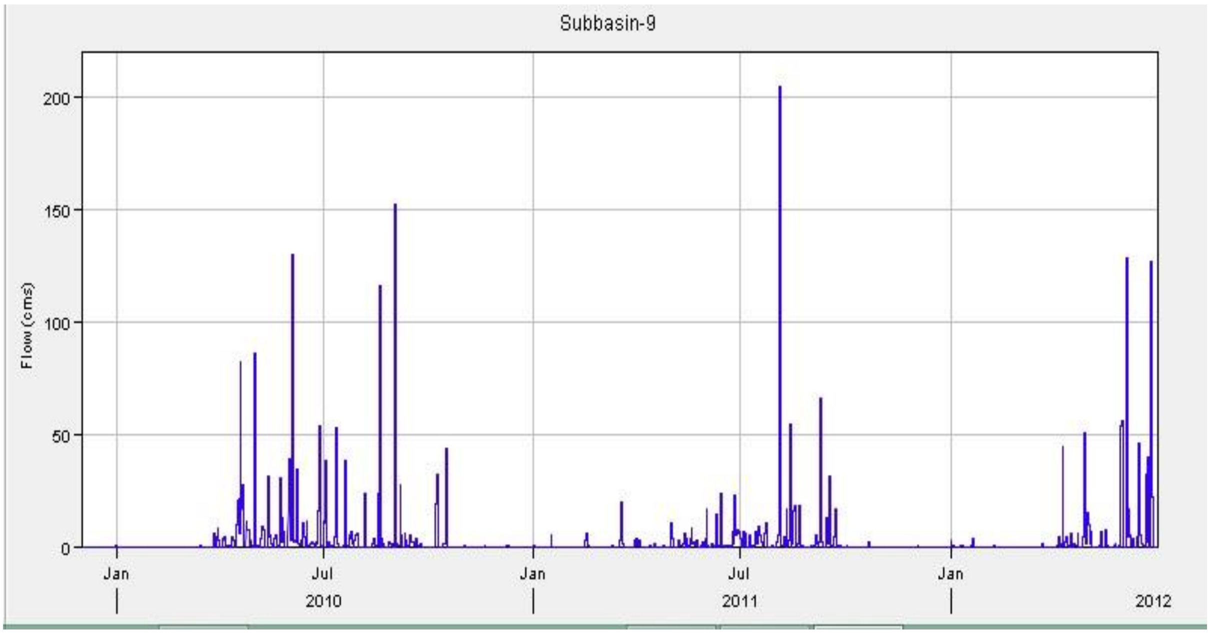



**Figure-17:** discharge of sub-basin 9

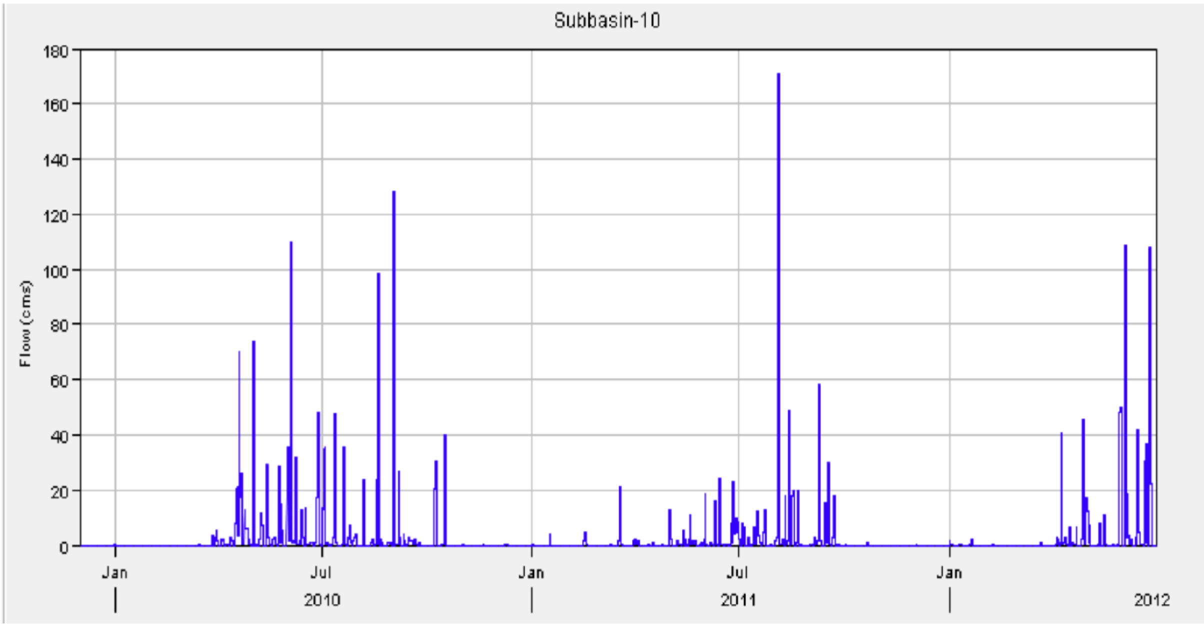



**Figure-18:** discharge of sub-basin 10

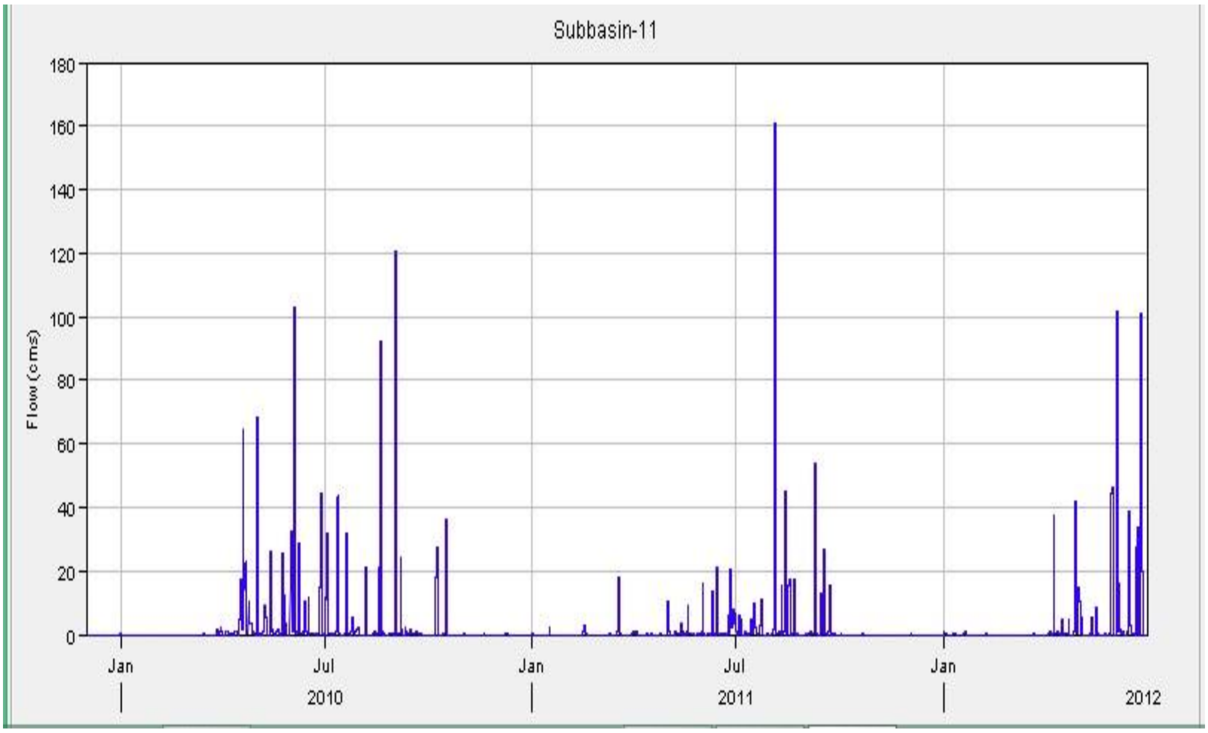
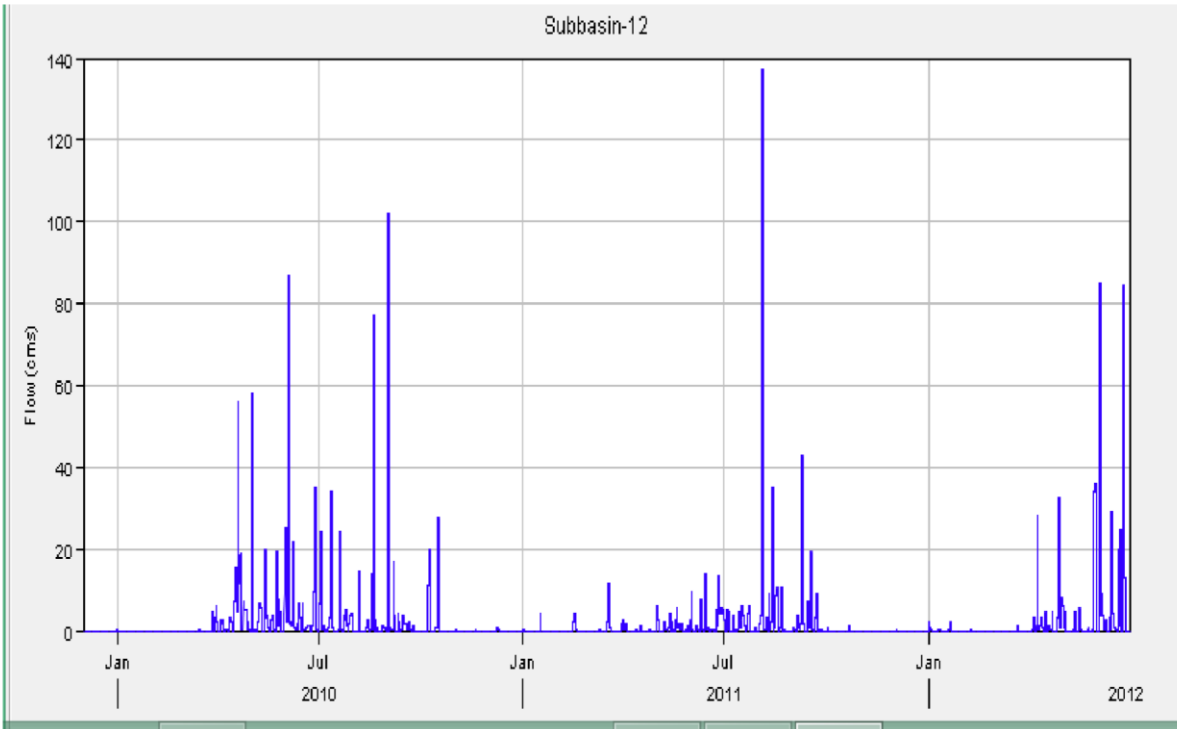



**Figure-19:** discharge of sub-basin 11




**Figurre-20:** discharge of sub-basin 12

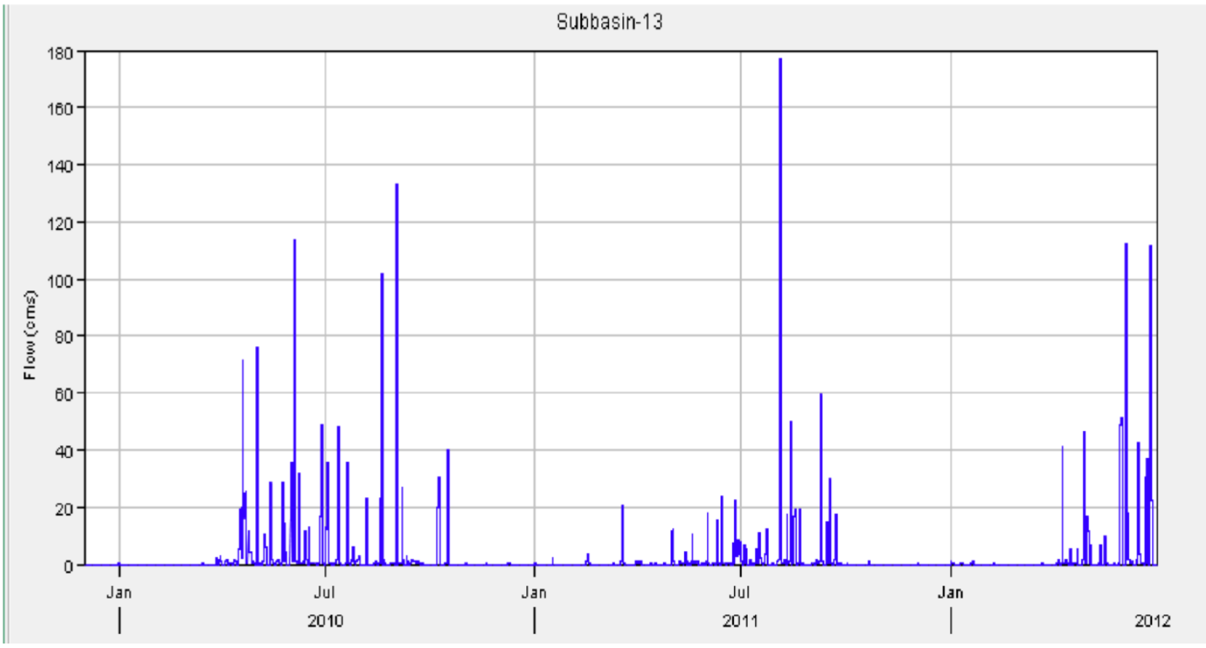



**Figure-21:** discharge of sub-basin 13

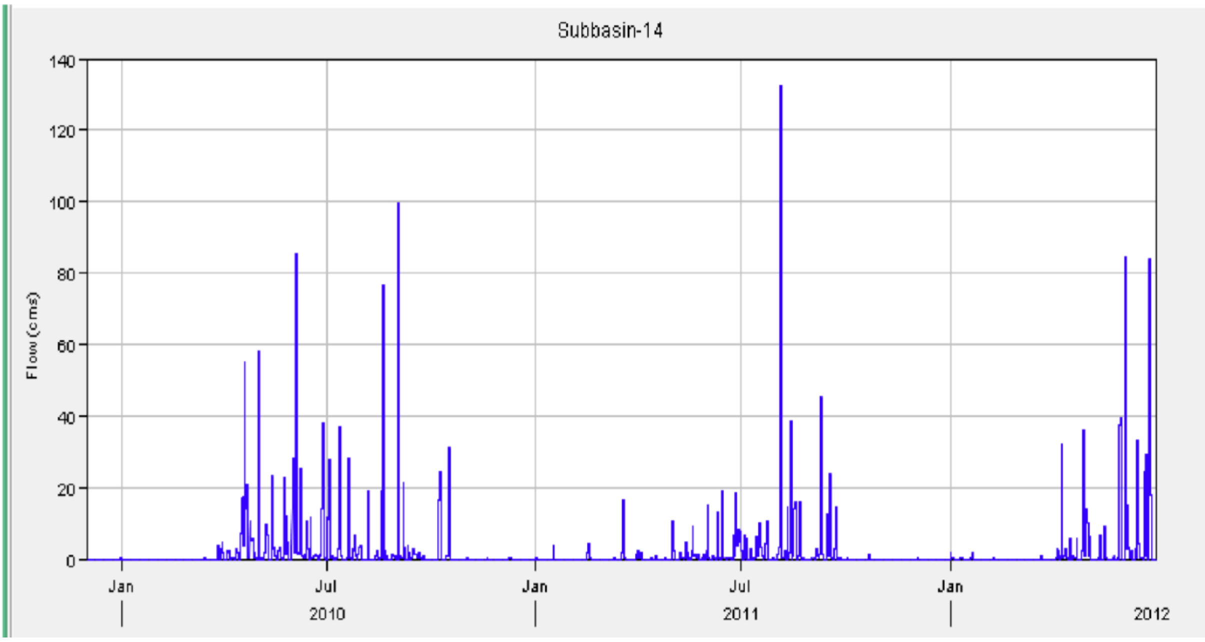



**Figure-22:** discharge of sub-basin 14

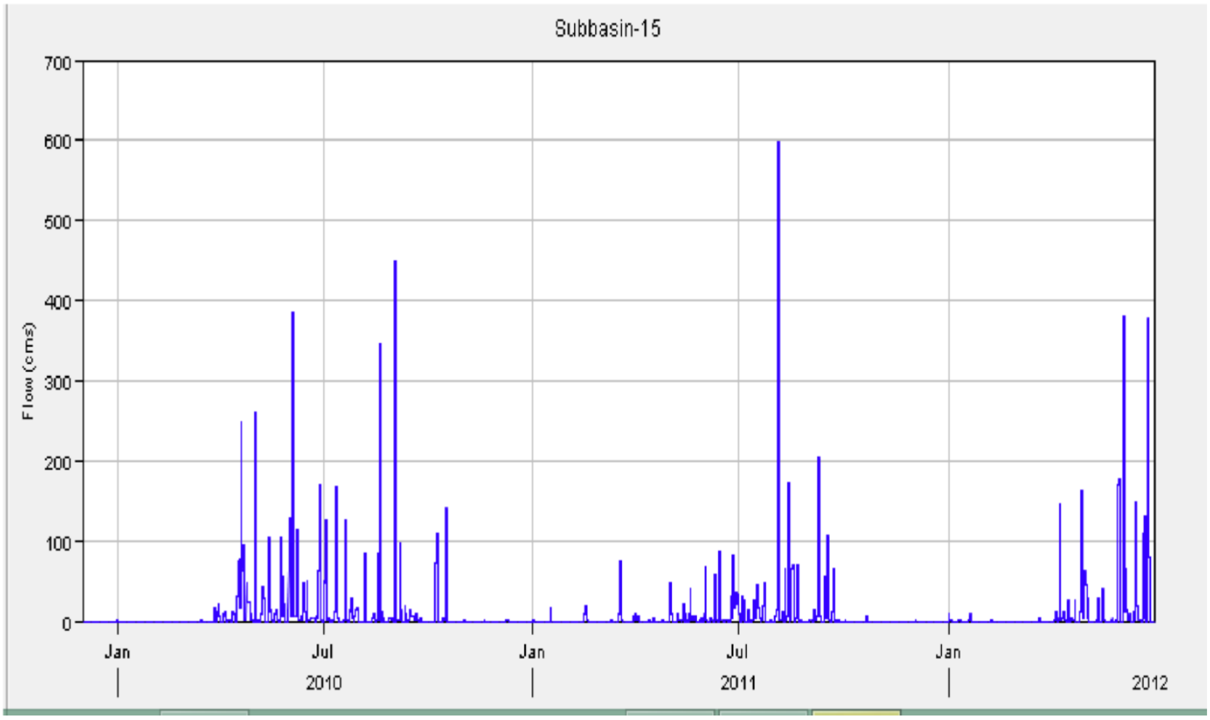



**Figure-23:** discharge of sub-basin 15

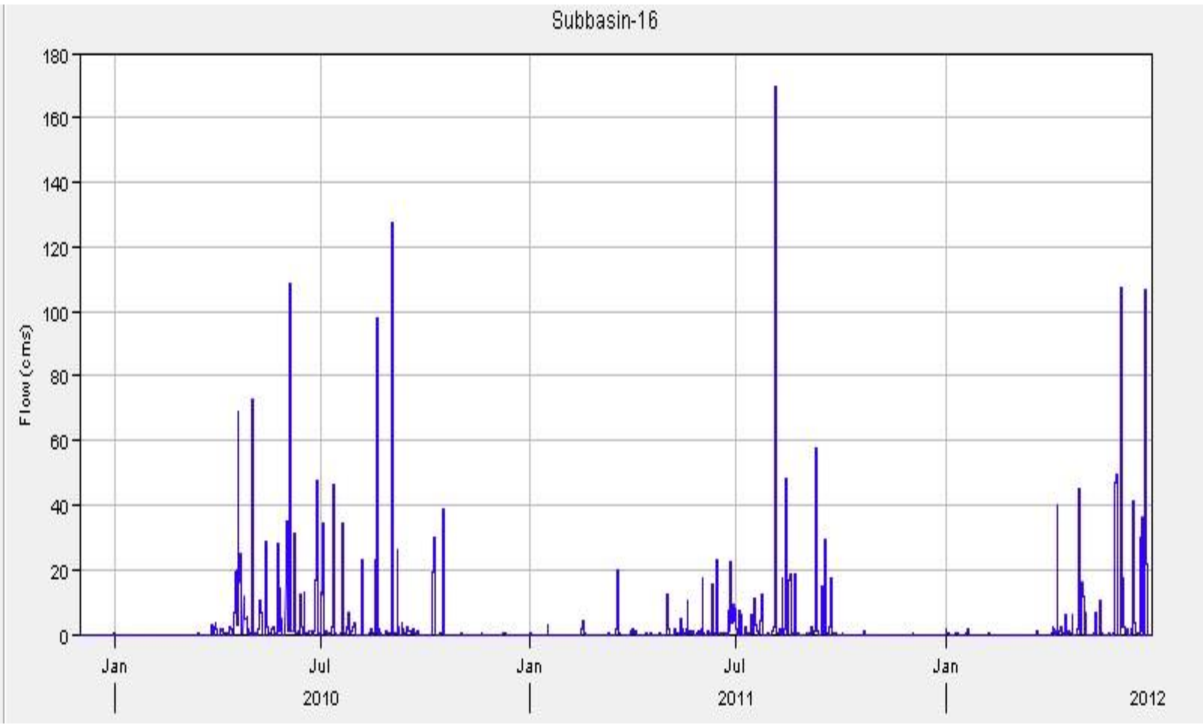



**Figure-24:** discharge of sub-basin 16

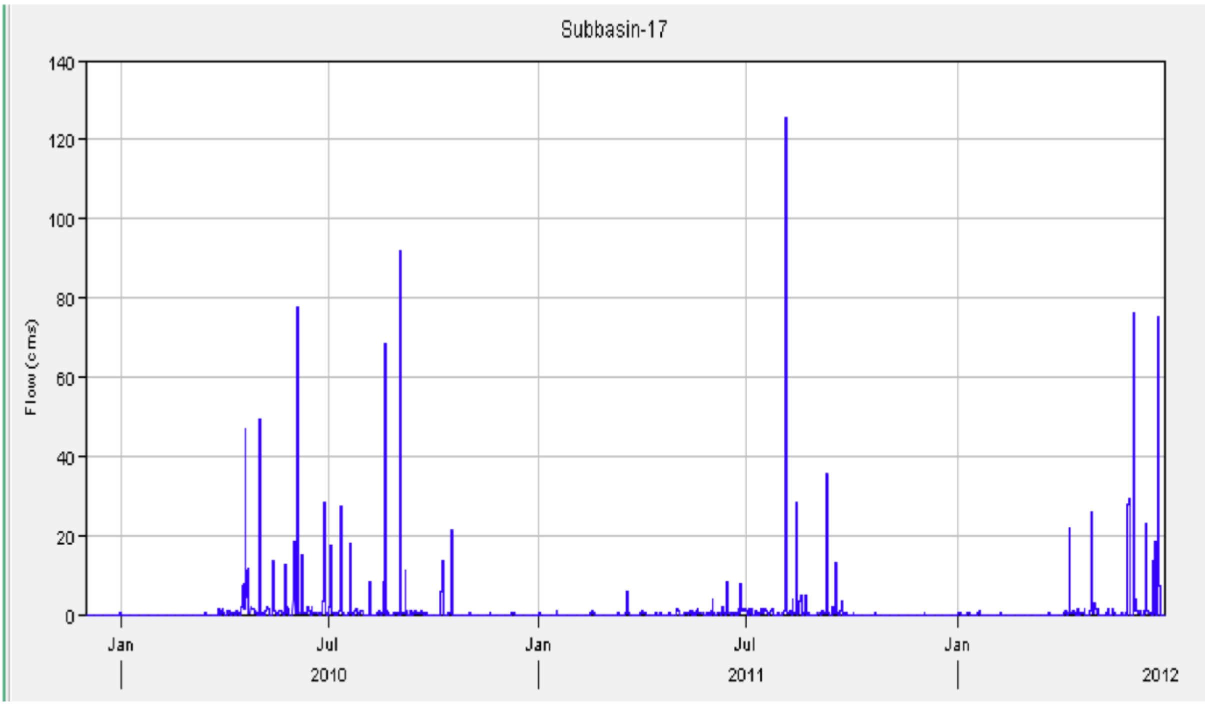



**Figure-25:** discharge of sub-basin 17

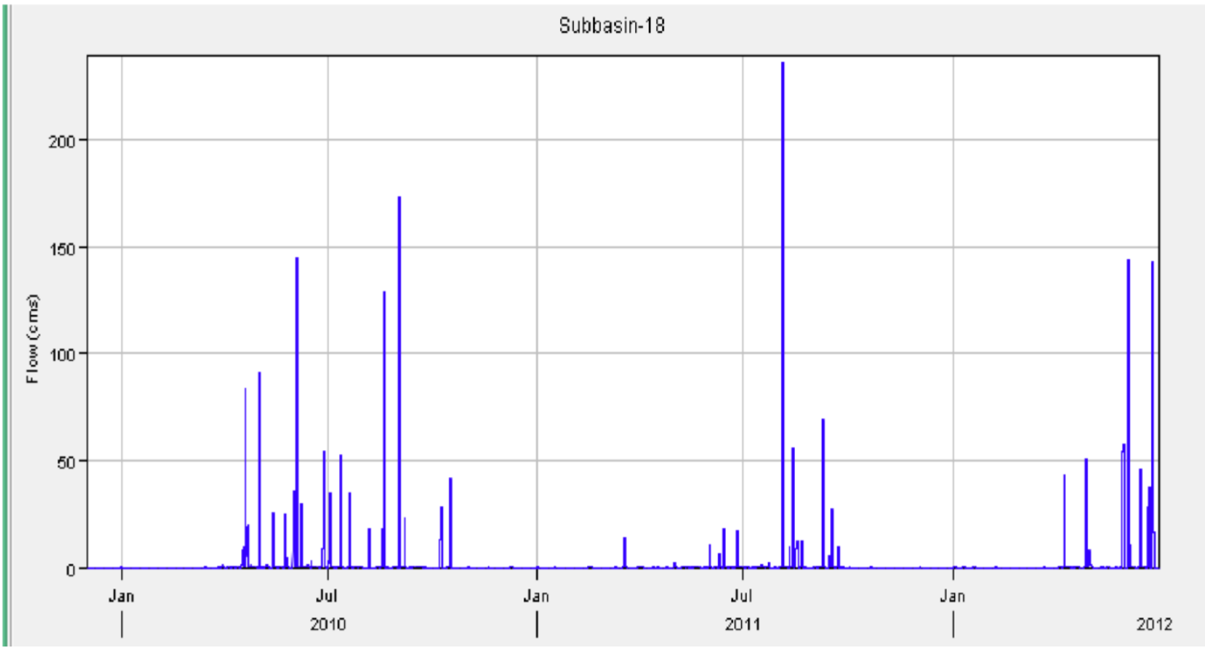



**Figure-26:** discharge of sub-basin 18

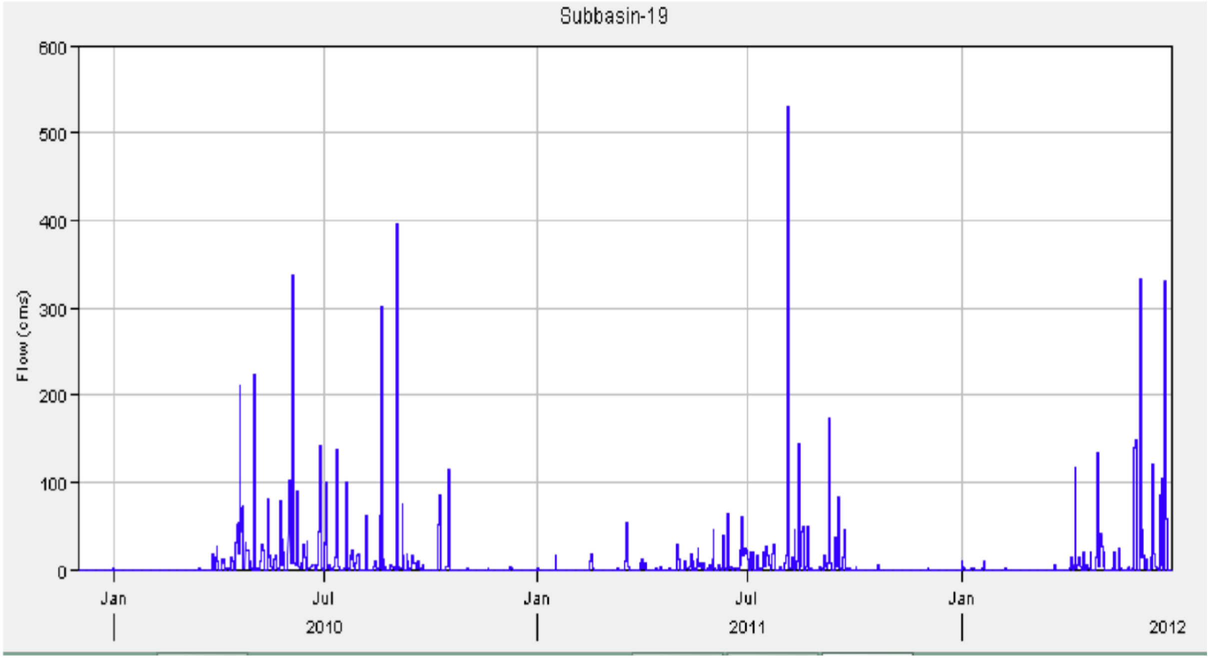



**Figure-27:** discharge of sub-basin 19

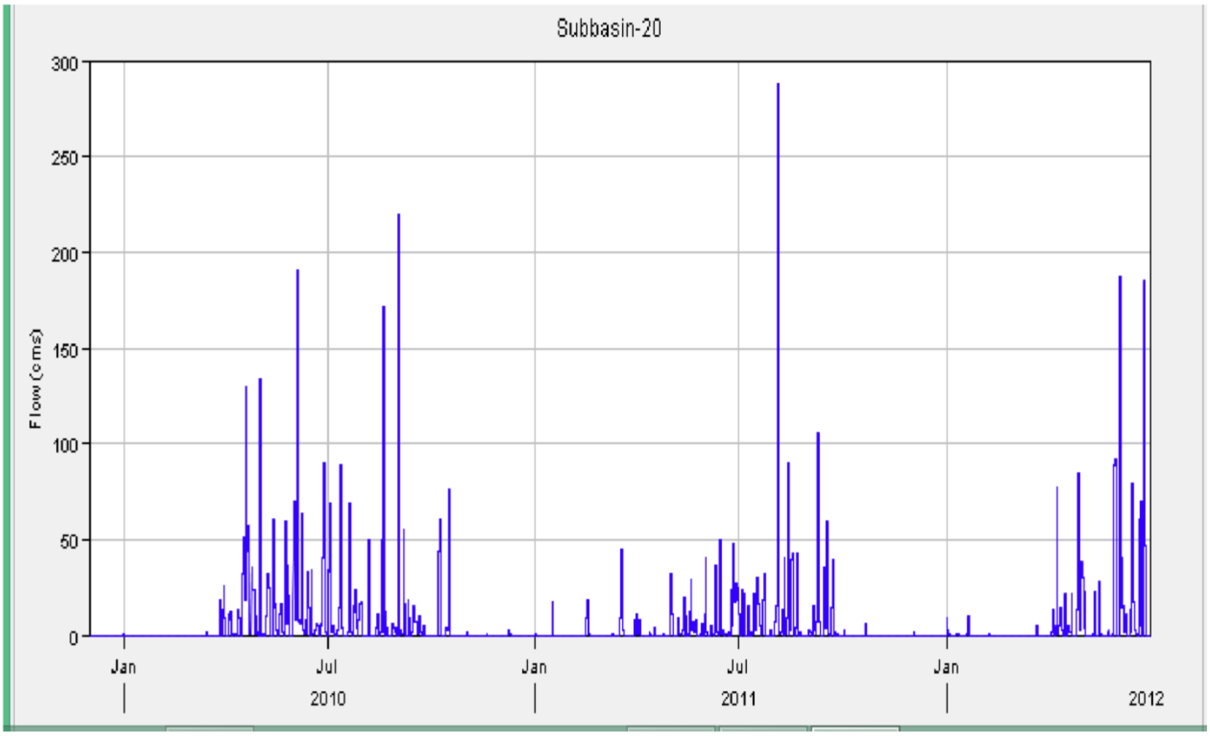



**Figure-28:** discharge of sub-basin 20

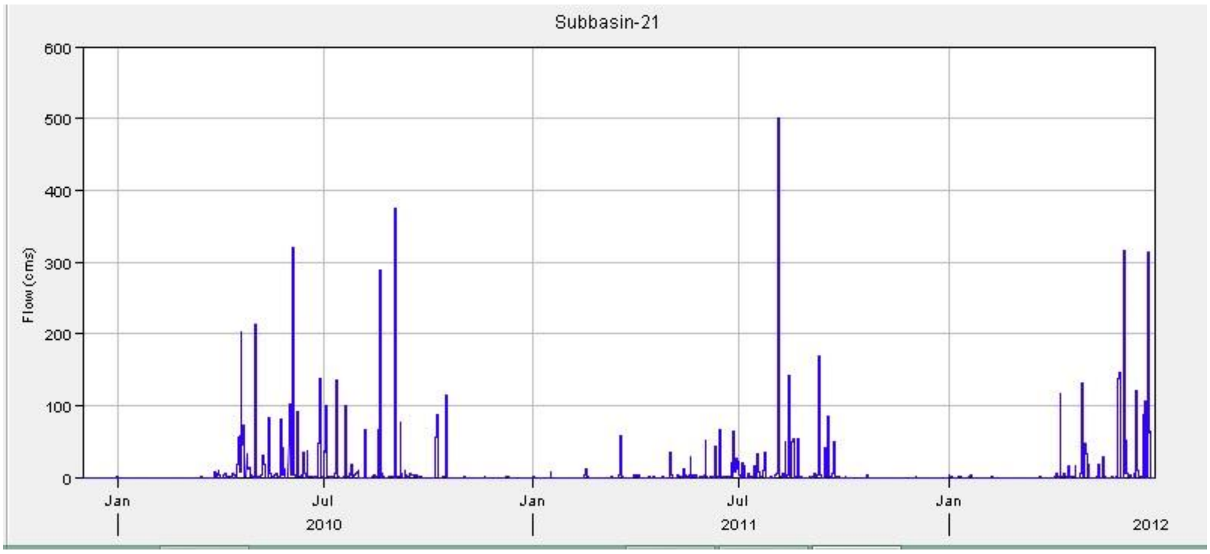



**Figure-29:** discharge of sub-basin 21

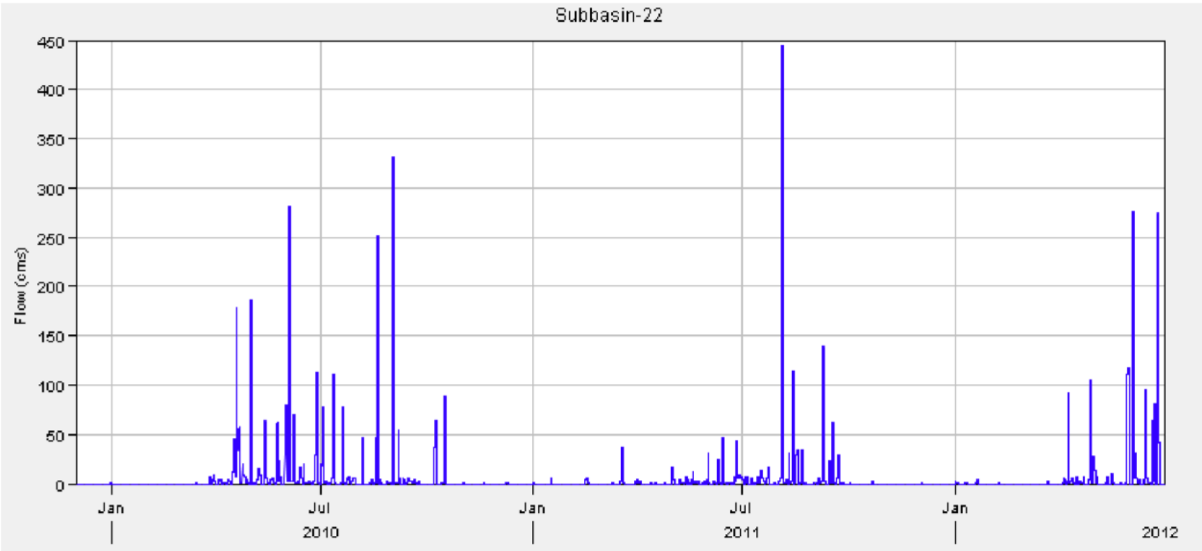



**Figure-30:** discharge of sub-basin 22

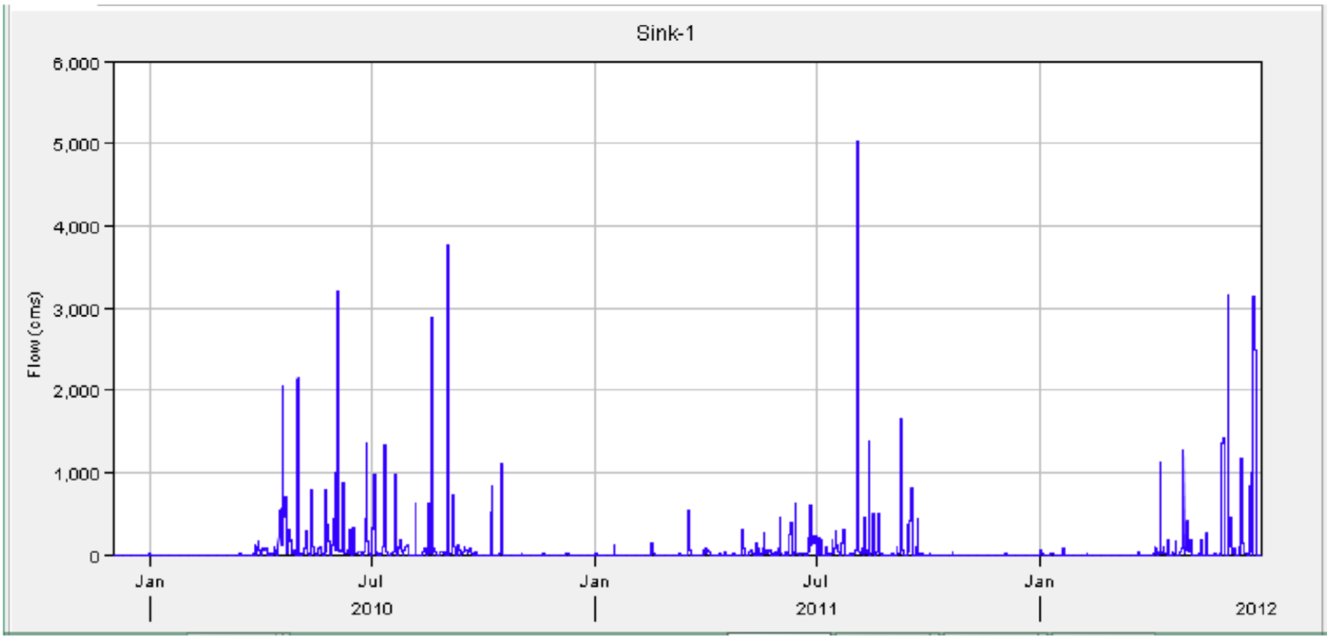



**Figure-31:** discharge at the outlet of the Silsako watershed

## 5.3 Discussion

Figure 8 shows the soil infiltration loss of the sub basin 1, that given in mm. Figure 9 shows the discharge of sub-basin 1 about 175 $m^3/s$, Figure 10 shows the discharge in sub-basin 2 about 270 $m^3/s$, figure 10 shows sub-basin 3 gives discharge about 178 $m^3/s$, figure 11 shows the discharge in sub-basin 4 about 87 $m^3/s$.

Figure 12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30 gives the discharges about 138 $m^3/s$ , 122 $m^3/s$, 60 $m^3/s$,122 $m^3/s$ ,202 $m^3/s$, 170 $m^3/s$, 160 $m^3/s$, 138 $m^3/s$,179 $m^3/s$,135 $m^3/s$,600 $m^3/s$,170 $m^3/s$,125 $m^3/s$,249 $m^3/s$, 520 $m^3/s$,270 $m^3/s$,500 $m^3/s$,450 $m^3/s$ respectively..

Figure 31 shows the outlet where all the water is collected from all 22 sub-basin gives discharge about 5020 $m^3/s$.

## 5.4 Conclusion

The HEC–HMS is applicable for disaster mitigation, flood control, and water management in medium-size river basins. The ability of HEC–HMS to simulate the magnitude and timing of the peaks in extreme floods in the river basin that underscores the significance of the model's application as a flood prediction tool. The model cab be useful as a tool to issue early warnings in the lower river basin during extreme rainfall conditions in the upper basin. The ability of HEC–HMS is to simulate long-term daily flow, which shows its applicability as a tool for planning water resources development in the lower River basin. The HEC–HMS successfully reproduces low flows and, thus is a useful tool to estimate low flows in advance on the basis of drought forecasts. The HEC–HMS can be useful for analyzing future extreme conditions by taking advantage of the characteristics of distinct modeling approaches with the availability of various data hence is suitable for our study. In the current study, the peak discharge at the outlet due to corresponding simulation is found to be 6793815.6 $m^3$.

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